2021 HKDSE Physics & Combined Science (Physics)

Report on Assessment

Y.T.SZETO
Manager (Physics), HKEAA

4 & 5 Oct 2021

Overview

Paper	Physics	CS(Phy)
1A (MC)	Mean: 19.1 out of 33 (i.e. 58%) (2020: 17.5 out of 33)	Mean: 9.4 out of 22 (i.e. 43%) (2020: 8.9 out of 22)
1B	~<50% (2020: ~50%)	~<35% (2020: ~35%)
2	~50% (2020: ~<50%)	N.A.
SBA	N.A.	N.A.
Candidature	ALL: 9 366 SCH: 8 712	ALL: 136 SCH: 125

Marking & Grading

On-Screen Marking (OSM) panels	
Physics	**CS(Phy)**
1B-1: Q.1, 3, 4 (27M) 1B-2: Q.6, 7, 8 (34M) 1B-3: Q.2, 5, 9 (23M)	1B-1: Q.1, 2, 3 (27M) 1B-2: Q.4, 5, 6 (29M) ---
2A: Astronomy (17%) 2B: Atomic World (64%) 2C: Energy (87%) 2D: Medical Physics (32%)	---

SBA CANCELLED

Marking & Grading

- Expert Panel (4 ~ 5 Examiners) determine level boundaries/ cut scores based on **Level descriptors / Group Ability Indicator (GAI) / Viewing candidate samples**.
- CS(Phy) graded by **Common items & GAI / Viewing candidate samples.**
- Endorsement by Senior Management/Public Exam. Board

Note: GAI is generated from Physics candidates' actual percentage awards in 4 core subjects CEML taken into consideration the correlation between Physics and CEML.

Results

Cut score difference Δ = 53.2 %

Physics

Level	5**	5+	4+	3+	2+	1+
Percentage	2.7%	27.7%	49.8%	72.3%	90.1%	98.0%

No. of MC	29	25	20/19	14	10	6

Cut score difference Δ = 48.8 %

CS(Phy)

Level	5**	5+	4+	3+	2+	1+
Percentage	1.5%	5.9%	19.9%	50.7%	75.0%	91.9%

No. of MC	19	15	13/12	9	7	5

Paper 1A

Physics (33 MC)

>70%	50%-70%	<50%
7	16	10

Easy Difficult

CS (Phy) (22 MC)

>70%	50%-70%	<50%
1	5	16

Easy Difficult

Paper 2 (MC)

Easy Difficult

Astro (48%)

>70%	50%-70%	<50%
0	4	4

Atomic (48%)

>70%	50%-70%	<50%
0	5	3

Energy (62%)

>70%	50%-70%	<50%
2	5	1

Medical (50%)

>70%	50%-70%	<50%
1	4	3

Average % correct in brackets

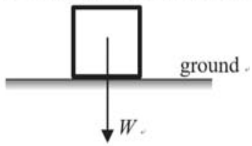
PHYSICS MC

Topic (No. of Qu.)	Average % correct	No. of Qu. < 50% correct
Heat & Gases (3)	64%	0
Force & Motion (6)	49%	3
Wave Motion (11)	61%	2
Electricity & Magnetism (10)	55%	4
Radioactivity (3)	69%	1

CS(PHY) MC

Topic (No. of Qu.)	Average % correct	No. of Qu. < 50% correct
Heat & Gases (2)	52%	1
Force & Motion (5)	33%	5
Wave Motion (9)	46%	7
Electricity & Magnetism (6)	43%	3

4. A block of weight W is at rest on a horizontal ground as shown.



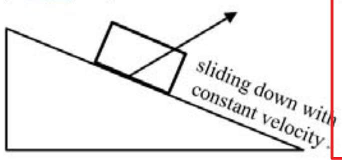
The force acting on the block by the ground is R. Which of the following statements is/are correct ?

(1) R and W are opposite in direction.
(2) R and W are equal in magnitude.
(3) R and W is an action-and-reaction pair.

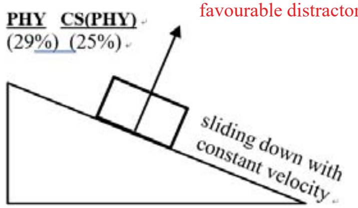
			PHY	CS(PHY)
A.	(1) only		(3%)	(5%)
*B.	(1) and (2) only		(43%)	(32%)
C.	(2) and (3) only		(1%)	(0%)
D.	(1), (2) and (3)	favourable distractor	(53%)	(63%)

5. A block is sliding down a rough incline with constant velocity as shown. Which arrow indicates the direction of **the resultant force acting on the block by the incline** ? Neglect air resistance.

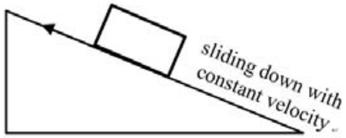
A. PHY CS(PHY) (13%) (14%)



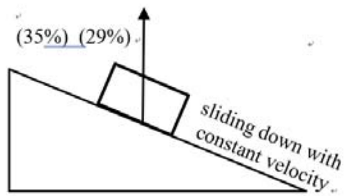
B. PHY CS(PHY) (29%) (25%) favourable distractor



C. (23%) (32%)



*D. (35%) (29%)



Just over one-third of the candidates realised that the resultant force from the incline acting on the block in uniform motion should balance the block's own weight.

8. A stationary uranium nucleus $^{238}_{92}U$ decays to give a thorium nucleus $^{234}_{90}Th$ and an α particle $^{4}_{2}He$.

$$^{238}_{92}U \longrightarrow {}^{234}_{90}Th + {}^{4}_{2}He$$

Which of the following correctly describes the situation about the $^{234}_{90}Th$ nucleus and the α particle just after the decay ?

	magnitude of momentum p	kinetic energy KE		PHY	CS(PHY)
*A.	$p(Th) = p(\alpha)$	$KE(Th) < KE(\alpha)$		(44%)	(23%)
B.	$p(Th) > p(\alpha)$	$KE(Th) > KE(\alpha)$		(18%)	(30%)
C.	$p(Th) = p(\alpha)$	$KE(Th) > KE(\alpha)$	favourable distractor	(29%)	(37%)
D.	$p(Th) = p(\alpha)$	$KE(Th) = KE(\alpha)$		(9%)	(10%)

While over 80% of the candidates indicated knowledge that the momentum of the two decay products is equal in magnitude, just over 40% of them knew that most of the kinetic energy goes to the lighter α-particle.

20. Submarines employ ultrasound instead of microwaves to detect obstacles in the sea. This is because

			PHY	CS(PHY)
A.	wavelengths of ultrasound are shorter than those of microwaves.		(17%)	(15%)
B.	ultrasound travels faster than microwaves in the sea.		(24%)	(42%)
*C.	microwaves are easily absorbed by sea water.		(33%)	(16%)
D.	microwaves diffract too much in the sea.	favourable distractor	(26%)	(27%)

Just about one-third of the candidates knew the reason why microwaves are not used for detection in the sea.

22. When a point charge $+Q$ is placed at X as shown, the strength of the electric field at Y is E_0.

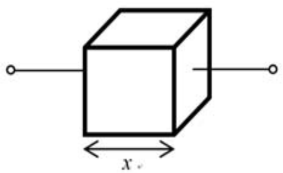
If W and Z are each placed with a point charge of $+Q$, what will be the electric field strength at Y ?

Note: $\sin 45° = \cos 45° = \frac{\sqrt{2}}{2}$

*A.	$\frac{\sqrt{2}}{2} E_0$		(28%)
B.	E_0		(23%)
C.	$\sqrt{2}\, E_0$	favourable distractor	(38%)
D.	$2\, E_0$		(11%)

Less than 30% of the candidates were able to compute the vector sum of the electric fields contributed by the point charges.

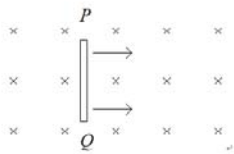
24. The figure shows a metallic cube of side length x. How is its resistance R between any two opposite faces related to x ?



			PHY	CS(PHY)
*A.	$R \propto \frac{1}{x}$		(45%)	(33%)
B.	$R \propto x$		(15%)	(15%)
C.	$R \propto x^2$		(15%)	(27%)
D.	$R \propto \frac{1}{x^2}$	favourable distractor	(25%)	(25%)

Candidates choosing option D suggests that they have only considered the cross-reaction of the cube and overlooked the contribution of its length.

26. When a copper rod PQ moves with a constant velocity across a uniform magnetic field as shown, an e.m.f. is induced across the rod.



Which of the following statements is/are correct ?

(1) The magnitude of the induced e.m.f. depends on the length of the rod.
(2) Rod PQ acts like a cell providing an e.m.f. with P being its positive terminal.
(3) There is a force acting on the rod to oppose its motion.

A.	(1) only		(22%)
B.	(3) only	favourable distractor	(21%)
*C.	(1) and (2) only		(35%)
D.	(2) and (3) only	favourable distractor	(22%)

Over 40% of the candidates wrongly held that statement (3) is correct. They were not aware that no induced current flows in the rod and therefore no opposing force results.

33. Which of the following may contain sources of ionizing radiations ?

(1) sea water
(2) a rock sample
(3) human body

A.	(1) only		(8%)
B.	(2) only	favourable distractor	(32%)
C.	(2) and (3) only		(12%)
*D.	(1), (2) and (3)		(48%)

Less than half of the candidates answered correctly. It seems that they were not familiar with the various natural sources of radiations in the environment.

Strengths & Weaknesses of Candidates

- Strengths:
  - competent in calculations although some employed tedious methods
  - most simple questions answered well
- Weaknesses:
  - quite weak in handling units
  - qualitative responses far from precise
  - not paying attention to details when drawing diagrams

Points to note

- Paper 1: ~70% core part
- Method marks 'M' and Answer marks 'A' (with tolerance range) adopted.
- Accept BOTH $g = 9.81$ or $10\ \mathrm{m\ s^{-2}}$.

Points to note

- Electives (Total = 80 each) equating using Paper 1

Before equating: Mean 29 to 37 / SD 17 to 21
After equating: Mean 37 to 43 / SD 18 to 21

2A Astronomy: ↑↑
2B Atomic World: ↑↑
2C Energy: ↑
2D Medical Physics: ↑

Points to note

- Samples of performance of candidates available in late October (HKEAA website).
- SBA cancelled for DSE Phy 2022, resumed for 2023 cohort (i.e. currently S5)
- 2022 DSE Phy Exam on 5 May 2022

Markers' Mtg:	Paper 1B	13/5
(tentative)	Paper 2	12/5

THANK YOU

HKDSE PHYSICS SEMINAR (4 & 5 OCT 2021)

DSE PHYSICS 1B – Q1, 3, 4

1. A 150 W immersion heater is used to keep the water in a large beaker boiling under standard atmospheric pressure. In 5 minutes, 16 g of water boils away. Neglect any heat loss to surroundings.

(a) Find the specific latent heat of vaporization of water, l. (2 marks)

Suggested Solutions	Students' Responses
$Pt = ml$ $l = \frac{150\times(5\times60)}{0.016}$ $= 2810$ kJ kg^{-1}	By $E = lm$, $pt = l_v m$ $(\frac{5}{60})\ 150 = (\frac{16}{1000})(l_v)$ ✗ $l = 781.25$ J kg^{-1} // 0 $Pt = m\Delta l$ $(150)(300) = (0.016)\ l$ ✓ $l = 2.8125 \times 10^6$ J ✗ 1

A student puts a small metal sphere in the boiling water. After a few minutes, the sphere is quickly transferred to a polystyrene cup containing 100 g of water at a temperature of 20 °C. The cup of water is stirred gently and its highest temperature attained is 22 °C.

Given: specific heat capacity of water = 4200 J kg^{-1} °C^{-1}

(b) Estimate the heat capacity *C* of the metal sphere. (2 marks)

Suggested Solutions	Students' Responses
$C(100-22) = m_w c_w (22-20)$ $C = \frac{0.100 \times 4200(22-20)}{(100-22)}$ $= 10.8$ J °C^{-1}	$C(100-22) = (0.1)(4200)(22°-20°)$ $C = 10.76$ J C^{-1} 1 $mc\Delta T = C\Delta T_m$ $100 \times 10^{-3} \times 4200 \times 2 = C \times 2$ $C = 4200$ J °C^{-1} 0

(c) In fact the sphere has carried with it some boiling water to the cup of water. Referring to this fact, explain whether the true value of *C* is higher or lower than the value calculated in (b). (2 marks)

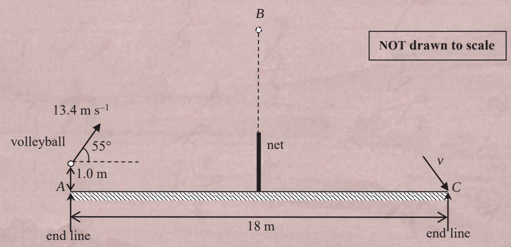
Suggested Solutions	Students' Responses
Extra energy is transferred to the cup of water by the boiling water. / The *final temperature* of the cup of water is *higher*. The true value of C is *smaller than* the calculated value.	Not all energy gained comes from the metal sphere, so the energy loss by the metal sphere is smaller than 840 J. Since $C = \frac{Q}{\Delta T}$, the true value of C would be smaller. 2 The actual energy released by the metal sphere is smaller. ∴ The true value of C is lower than the value in (b) 2 The true value will higher than the value calculated in (b). It is because the energy loss from metal sphere is larger than them. 0

(d) In order to reduce the error contributed by the polystyrene cup, another student suggests repeating the measurements using a copper cup of similar shape and size. Explain whether the suggestion is justified. (2 marks)

Suggested Solutions	Students' Responses
Not justified Copper is a good conductor so more energy is lost to the surroundings / Polystyrene is a good insulator so less energy is lost to the surroundings	It is not justified. Copper is a good conductor of heat. There will be a significant heat loss of the water in the cup to the surrounding air by conduction. The error will be larger than that of polystyrene cup as polystyrene cup is a good insulator of heat thus heat loss to the surrounding air is reduced. 2

Students' Responses
Yes, because the copper cup is good heat conductor than polystyrene cup. 0
It's not justified. As copper is a heat conductor, the heat of ~~cup~~ water inside the cup will transfer heat to the copper cup, produces an error that make the heat capacity of sphere. 1

3. A volleyball player serves by hitting the ball from rest at a height of 1.0 m above the end line of the court. The initial speed of the ball is 13.4 m s^{-1} making an angle of 55° with the horizontal. It moves in a vertical plane perpendicular to the end line and finally reaches point *C* on the opposite end line as shown in Figure 3.1. Neglect the size of the ball and air resistance. (g = 9.81 m s^{-2})



(a) (i) The mass of the volleyball is 0.22 kg. Find the work done on the ball by the player. (2 marks)

Suggested Solutions	Students' Responses
Work done = K.E. gained = ½ (0.22) (13.4)^2 = 19.8 J	W.D. = KE_{gain} + PE_{gain} ✗ $= \frac{1}{2}(0.22)(13.4)^2 + (0.22)(9.81)(1 + 9\tan 55°)$ = 49.6 J 0

(ii) Determine the speed *v* with which the ball hits point *C* on the ground. (2 marks)

Suggested Solutions	Students' Responses
By conservation of mechanical energy: $\frac{1}{2} m v^2 - \frac{1}{2} m u^2 = mgh$ $v^2 - 13.4^2 = 2(9.81)(1.0)$ v = 14.1 m s^{-1} *By equations of motion*: $v_y^2 = u_y^2 + 2as$ $v_y^2 = (13.4 \sin 55°)^2 + 2(-9.81)(-1)$ v_y = 11.8 m s^{-1} Speed $v = \sqrt{v_x^2 + v_y^2}$ $= \sqrt{11.8^2 + (13.4\cos 55°)^2}$ = 14.1 m s^{-1}	work done = $\frac{1}{2}m(v_y)^2$ v_y = 4.43 m s^{-1} ✗ Speed hit C = $\sqrt{v_y^2 + v_x^2}$ $= \sqrt{4.43^2 + (13.4\cos 55°)^2}$ = 8.87 m s^{-1} 0

(b) The length of the court *AC* is 18 m and the net is positioned midway between *A* and *C*. It takes time *t* for the ball to reach point *B* which is vertically above the net.

(i) State whether the ball is ascending, flying horizontally or descending at *B*. (1 mark)

(ii) Find *t*. (2 marks)

Suggested Solutions	Students' Responses
(i) Descending	Flying horizontally ✗ ascending ✗ 0
(ii) 13.4 cos 55° × *t* = 18/2 *t* = 1.17 s	By $s_x = u_x t$ ✗ 18 = 13.4(cos 55°)(t) t = 2.341943457 s t ≈ 2.34 s 0

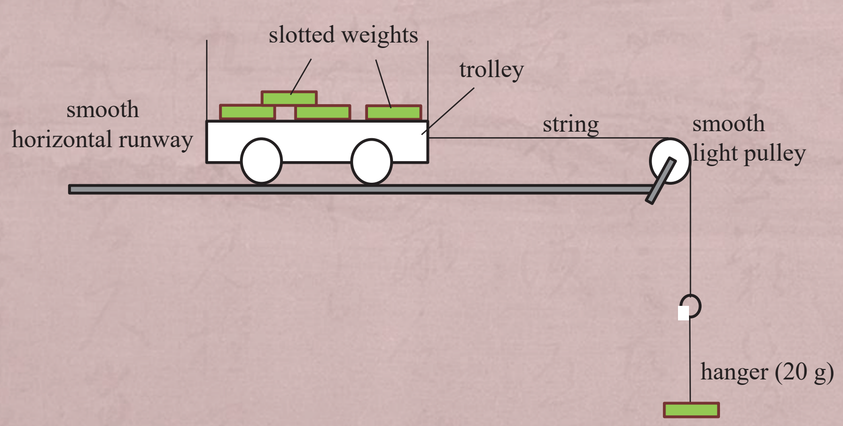
(c) Another player suggests that the volleyball can reach point *C* in a shorter time if it is served with a similar initial speed but at a smaller angle with the horizontal (e.g. 13.2 m s^{-1} at an angle of 35°). Without doing any calculation, explain whether this suggestion is justified. (2 marks)

Suggested Solutions	Students' Responses
Justified Horizontal component of the velocity increases and hence time of flight for the whole journey is smaller for the same horizontal distance.	not correct ✗. with a smaller angle, the horizontal speed will increase but the vertical speed will decrease, the ball may touch the net 0 It is justified. More ✗ energy is used in travelling horizontally when the angle is smaller. A higher speed ~~ca~~ is attained. 0 ~~Yes~~ The suggestion is justified because the horizontal speed is greater than before obviously. 1

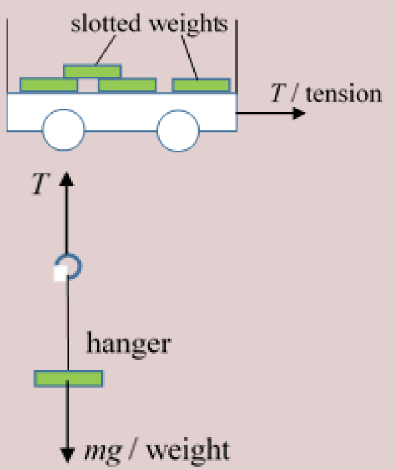
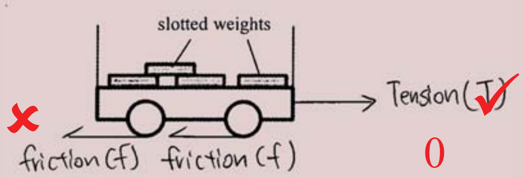
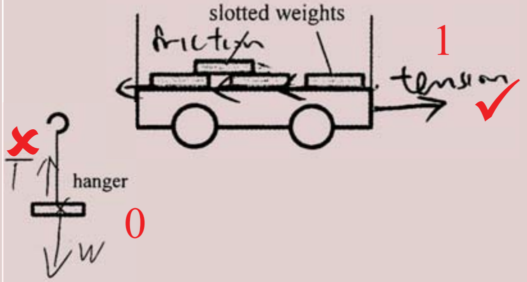
(d) Volleyball players have to jump and land frequently in a game. Referring to principles of mechanics, explain why volleyball courts with wood rather than concrete flooring may help to protect the players from injuries. (2 marks)

Suggested Solutions	Students' Responses
The time of impact for the wood floor is increased and hence the impact force is smaller.	The wood floor is much smooth than the concrete flooring. Less friction on the player is made by wood floor. As volleyball players have to jump and land frequently, less friction resistance can reduce their damage of knee on other movement like running. 0 By newton third law, when players land on ground, an reaction force from ground to player is formed, the mass of concrete is larger than wood, By F = ma, the force exerted will be larger. 0

4. A trolley is connected to a hanger of mass 20 g by a light inextensible string as shown in Figure 4.1. Four slotted weights, each of mass 20 g, are loaded onto the trolley. The experiment is designed to investigate the relationship between the net force acting on the system (trolley and slotted weights with hanger) and its acceleration. The acceleration a is measured after the trolley is released on the smooth horizontal runway.



(a) (i) After the trolley is released, indicate in the figures below (1) the horizontal force(s) acting on the loaded trolley, and (2) the force(s) acting on the hanger. (2 marks)

Suggested Solutions	Students' Responses
	 

(ii) Is the tension in the string equal to, greater than or smaller than the weight of the mass hanging when the system is released ? Explain. (2 marks)

Suggested Solutions	Students' Responses
Tension is smaller than weight. By Newton's second law, there is a net downward force acting on the hanger for its <u>*downward acceleration*</u>.	should be smaller than. the tension by the trolley is more from the hanger. While there is no friction of the trolley as the runway is smooth. This lower than the tension and be pulled by the weight of hanger. Thus it should be smaller. 1 Smaller. As the hanger will move downwards. Which means the weight is larger than tension. 1

(iii) By considering the motion of the whole system, or otherwise, write an equation relating m, a and mass M of the trolley. (1 mark)

Suggested Solutions	Students' Responses
By $F_{net} = m\,a$ $mg = (M + 0.1)\,a$	$mg = (m + M)\,a$ 0 $mg = a(0.08 + M + m)$ 0 $9.81m = (M + \frac{20}{1000} \times 4 - (m - \frac{20}{1000}) + m)\,a$ $9.81m = (M + 0.1)\,a$ 1

(b) Calculate the slope of the graph. Hence find M using the result of (a)(iii). (3 marks)

Suggested Solutions	Students' Responses
slope of the graph $= \frac{2.5}{0.1} = 25$ (m s^{-2} kg^{-1}) $mg = (M + 0.1)\,a$ $a = \frac{g}{M+0.1} \times m$ $\therefore$ slope of the graph $= 25 = \frac{9.81}{M+0.1}$ $M = 0.292$ kg	Slope of the graph $= \frac{2.5-0}{0.100-0}$ $= 25$ $Ma = mg$ $M\frac{a}{m} = 9.81$ $25M = 9.81$ $M = 0.3924$ kg 2 Slope $= \frac{2.5-0}{0.1-0} = 25$ ms^{-2} kg^{-1} $25 = \frac{9.81}{0.1+M}$ (9.81) $M = 0.2924$ kg 2

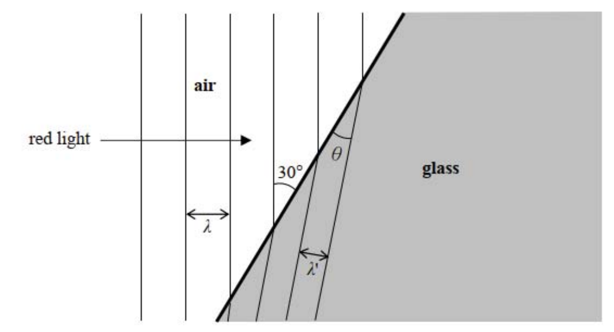
THANKS

2021 HKDSE - Physics

1B - QUESTIONS 6, 7 & 8

6. (a) When red light of wavelength λ = 675 nm is incident at an angle of 30° from air to glass as shown in Figure 6.1, refraction occurs such that its wavelength in glass becomes λ' = 450 nm while the angle of refraction is θ.

Figure 6.1



6. (a) (i) What is the frequency of the red light in glass ?

MS

(a) (i)	$f = \frac{c}{\lambda}$		
	$= \frac{3\times10^8}{675\times10^{-9}}$	1M	1M for correct substitution
	$= 4.444444 \times 10^{14}$ Hz $\approx 4.44 \times 10^{14}$ Hz	1A	
		2	

Not as well answered as expected.

Candidate's Response

$3\times10^8 = f(675\times10^{-9})$
$f = 4.44\times10^{14}$ $\boxed{s^{-1}}$

1M
1A

What is the frequency of the red light in glass ?

$v = f\lambda$
$3\times10^8 = f(675\times10^{-9})$
$f = 4.44\times10^{14}$ Hz

$\frac{f'}{f} = \frac{450\times10^{-9}}{675\times10^{-9}}$
$f' = 2.96\times10^{14}$ Hz

0M
0A

By $v = f\lambda$
$3\times10^8 = f\boxed{(450\times10^{-9})}$
$f = 6.6667\times10^{14}$ Hz
$\approx 6.67\times10^{14}$ Hz

0M
0A

Make sure the correct v and λ are selected when using wave equation.

The frequency of light is irrespective of the medium concerned.

6. (a) (ii) Find θ.

MS

(ii)	$\frac{\sin 30°}{\sin\theta} = \frac{c}{v} = \frac{\lambda}{\lambda'}$		
	$= \frac{675}{450}$	1M	1M for correct substitution
	$\sin\theta = \left(\frac{450}{675}\right)\sin 30°$		
	$\theta = 19.471° \approx 19.5°$	1A	
		2	

Candidate's Response

v in glass
$v = (4.44\times10^{14})(450\times10^{-9})$
$v = 200000000$ ms^{-1}
$n = \frac{c}{v}$
$n = 1.5$
$\sin 30° = 1.5\sin\theta$
$\theta = 19.5°$

1M
1A

$\sin 60° = \frac{675}{450}\sin(90°-\theta)$
$\theta = 54.7°$

0M
0A

Care needs to be taken in identifying the correct angles of incidence and refraction.

$d\sin\theta = n\lambda$
$d\sin 30° = (1)(675)$
$d = 1350$
$1350\sin\theta = (1)(450)$
$\theta = 19.47122$
$\theta \approx 19.5°$

0M
0A

Misconception

6. (a) (iii) If the red light is replaced by blue light, θ will decrease. Compare the refractive index of glass for the red light and blue light.

MS

(iii)	The refractive index of glass for blue light is greater (than that for red light).	1A	Accept : $n_b > n_r$
		1	

Candidate's Response

Well answered

Refractive index of glass for red light is smaller than that of blue light

1A

As λ of blue light shorter than that of red, refractive index would be smaller

0A

Misconception

6. (b) Figure 6.2 shows a system for projecting a transparent photographic slide O onto a screen. The slide and the screen are 1 m apart. A beam of white light illuminates the slide. The position of lens L is adjusted until a sharp image of O magnified linearly to 9 times is formed on the screen.

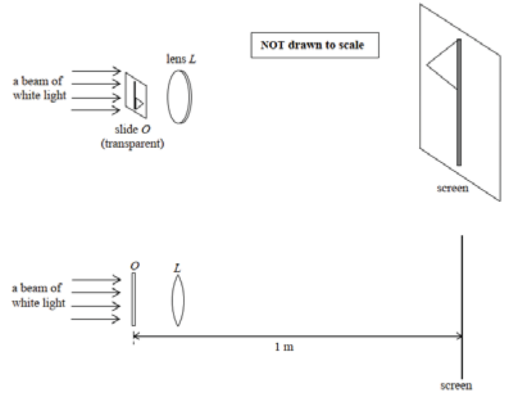


Figure 6.2

6. (b) (i) State the nature of this magnified image.
(ii) Find the separation between O and L.

MS

(b) (i)	real and/or inverted	1A	NOT accept : laterally inverted
		1	
(ii)	10 cm	1A	
		1	

Well answered

Candidate's Response

(b)(i) The image is inverted and virtual.

0A

(b)(ii) $\frac{v}{u} = 9$, $v = 9u$; $u + v = 1$, $9u + u = 1$, $u = 0.1\text{m}$

1A

OL : screen = 1 : $\sqrt{9}$

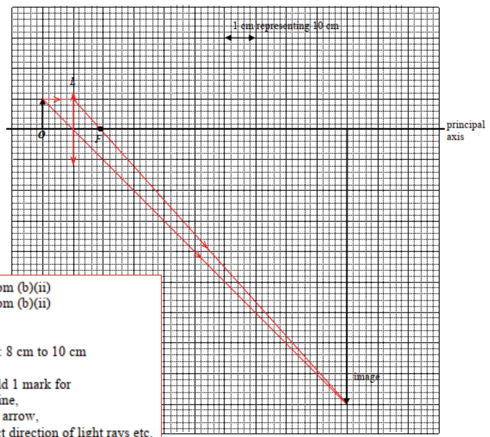
The separation between O and L = $\frac{1}{4}$ = 0.25m

0A

6. (b) (iii) Draw a ray diagram to show how the image of slide O is formed on the screen. Locate the focus F of lens L on your diagram and find the focal length of L. (Slide O and the principal axis of the lens have been drawn for you.)

MS

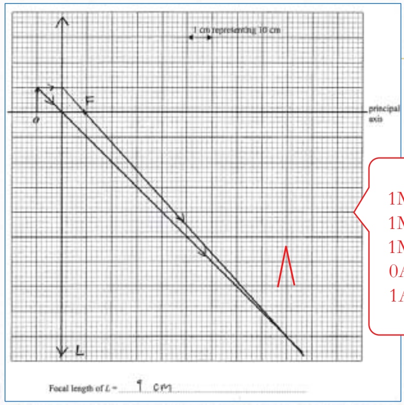
6. (b) (iii)



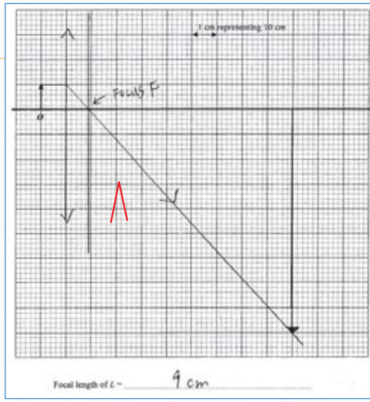
Location of F	1M	e.c.f. from (b)(ii)
Correct light rays from object to image	2M	e.c.f. from (b)(ii)
Correct position and size of image	1A	
Focal length of L = 9 cm	1A	Accept : 8 cm to 10 cm
		Withhold 1 mark for dotted line, missing arrow, incorrect direction of light rays etc.
	5	

6(b)(iii)

Candidate's Response



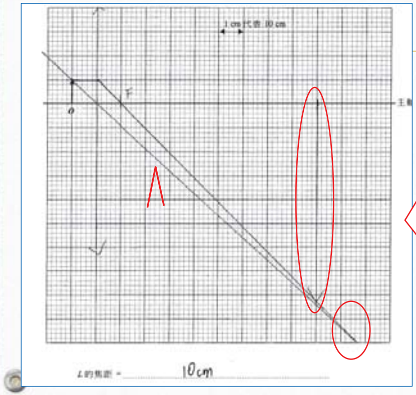
1M
1M
1M
0A
1A



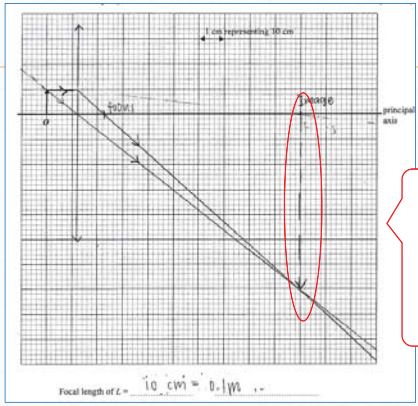
1M
1M
0M
1A
1A

6(b)(iii)

Candidate's Response



1M
0M
1M
0A
1A
-1



1M
1M
1M
0A
1A

6. (b) (iv) When a black-and-white slide is projected onto the screen, the image has colour edges. Explain briefly. (Hint: the lens is made of glass.)

MS

(iv)	White light composes of different colours. Since the refractive indices of glass (the medium of the lens) are different for different colours (i.e. dispersion),	1A	
	the sizes of the colour images on the screen are slightly different. When these images overlap on the screen, colour edges are seen.	1A	
		2	

Not as well answered as expected.

Candidate's Response

int: the lens is made of glass.) (2 mar

~~different colour~~ of light different colour have different ~~re~~ refractive index in glass. so the ~~a~~ angle of ~~diffe~~ refraction will be different between different colour.

0A
1A

The lens have refractive index, deffraction will occur, when some single color light rays pass through the lens, which will detract different color to the screen, forming image that has color edges.

0A
0A

Misconception

7. Read the following passage about **eddy currents** and answer the questions that follow.

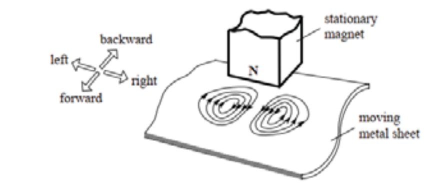
Eddy currents are induced by changing magnetic fields. They flow in closed loops in conductors like swirling eddies in a stream, perpendicular to the direction of the magnetic field. They are commonly applied in braking known as 'eddy braking'.

The heating effect of eddy currents is used in induction heating devices, such as induction cookers. The resistance felt by the eddy currents in a conductor causes Joule heating. However, for applications like motors and transformers, this heat is considered as a waste of energy and as such, eddy currents need to be minimized.

Eddy currents can be removed by cracks or slits in the conductor, which prevent the current loops from circulating. This means that eddy currents can be used in detecting defects in materials. The magnetic field produced by the eddy currents is measured, where a change in the field reveals the presence of an irregularity in the material.

7. (a) (i) In Figure 7.1, a permanent magnet with north pole facing downwards is held stationary. A metal sheet moves past the magnet (the direction of movement is not shown) and eddy currents are induced as shown. Briefly explain why eddy currents are induced and state whether the metal sheet is moving forward, backward, towards the left or towards the right.

Figure 7.1



MS

(a)	(i)	Eddy currents are induced to oppose the change of magnetic flux due to the movement of the metal sheet.	1A	Accept 'change of magnetic field'
		Moving to the left	1A	
			2	

7(a)(i)

Candidate's Response

Eddy currents are induced by changing magnetic field towards to left.

0A
1A

why the metal sheet is moved, there is a change in magnetic field on the sheet. By Lenz's law, an eddy current will oppose the change in magnetic field. The sheet is moving to the left

1A
1A

7. (a) (ii) State the energy changes in the process in which the metal sheet is slowing down to stop.

MS			
(ii)	Kinetic energy → Electrical energy → Internal (heat/thermal) energy	2A	
			2

Not as well answered as expected.

Candidate's Response

electrical energy → heat energy

1A
0A

The energy will change from electrical energy to kinetic energy

0A
0A

Mechanical ~~the~~ energy change into electrical ~~enenery~~ energy then change into heat energy

1A
0A

7. (a) (iii) Although eddy braking has the advantage of being **contactless**, traditional frictional braking cannot be totally replaced by eddy braking. Why ?

MS			
(iii)	Limitation: The eddy brakes only work when vehicle is moving. e.g. The vehicle cannot park in stationary positions/still on a slope.	1A	
			1

Poorly answered

Candidate's Response

traditional frictional braking can lock the car during parking while eddy braking cannot.

1A

As the speed of a car is decreasing, the effect of eddy braking is getting smaller. The braking force may not be large enough to stop the car in time.

1A

The resistance felt by eddy currents causes Joule heating, which is considered a waste of energy. Therefore, traditional frictional brecking can be more efficient

0A

7. (b) An induction cooker of rating '220 V, 2000 W' operates for 15 minutes. How much should be paid if 1 kW h of electrical energy costs $1.1 ?

MS			
(b)	Energy consumed = 2 kW × $\frac{15}{60}$ h = 0.5 kW h	1M	
	Cost = $ 1.1 × 0.5 = $ 0.55	1A	
			2

Well answered

Candidate's Response

E = 2000 × 15 × 60
= 18 00000 J
Cost = 1800000 / 3600000 × 1.1
= $ 0.55

1M
1A

2000 W ÷ 1000 kW = 2 kW
2(1.1)(15×60) = $1980

1M
0A

2000 × 15 × 60 ÷ 1000 ~~kW~~ ÷ 1.1 ÷ 60 ÷ 60
≈ $ 0.45

0M
0A

7. (c) State a method to minimize eddy currents produced in the iron cores of motors and transformers.

MS			
(c)	Lamination, i.e. the cores of these devices are made up of multiple insulated sheets of metal.	1A	
		1	

Candidate's Response

Use lamentated iron cores.

0A

Candidates should learn the correct spelling of scientific words.

We can make cracks or slits in the conductor, preventing the current loops from circulating.

0A

Cut the iron cores into many slits.

0A

Try to use correct scientific terms rather than a description of them.

7. (d) Eddy currents can be used to detect defects in materials. When there is a crack in a material, how would the magnetic field due to eddy currents change ? Explain briefly.

MS			
(d)	The magnetic field (produced by eddy currents) measured will decrease (where there are irregularities).	1A	
	It is because the crack will reduce the eddy currents.	1A	
		2	

Candidate's Response

No magnetic field will be produced. When there is a crack, since the circuit is incomplete, there is only induced e.m.f in the material but not current. No eddy current will be produced.

0A
0A

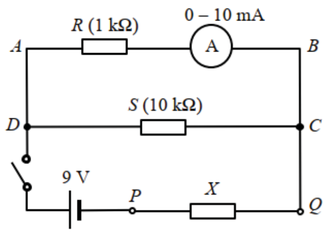
Ambiguous

The magnetic field change as the eddy current was affected or removed by the crack in a material.

0A
0A

8. Figure 8.1 shows a circuit for measuring the resistance of resistor X connected across P and Q. The resistance of resistor S is 10 kΩ. The internal resistance of the 9 V cell and that of the ammeter are negligible.

Figure 8.1



8. (a) When the switch is closed, the ammeter reads 8.5 mA.
(i) What is the p.d. between A and B ?

MS			
(a)	(i) $V_{AB} = (8.5 \times 10^{-3}\text{ A})\times(1\text{ k}\Omega)$ $= 8.5\text{ V}$	1M 1A	
		2	

Well answered

Candidate's Response

By $V=IR$
8.5×10
$= 8.5\text{mV}$

0M
0A

Make sure that the correct resistance is selected when using Ohm's law.

$V=IR$
$p.d = 1V(\Omega) \times 8.5 \times 10$
$= 85\text{ V}$

1M
0A

Be sure to know the standard SI prefixes and be able to apply the correct power of ten.

8. (a) (ii) Find the current passing through resistor *S*.

MS

(ii) Current through $S = \dfrac{8.5\text{ V}}{10\text{ k}\Omega}$ $= 8.50 \times 10^{-4}\text{ A} = 0.85\text{ mA}$	1M 1A 2	*AB*//*CD*, current through *S* $= (8.5 \times 10^{-3}\text{ A}) \times \dfrac{1\text{ k}\Omega}{10\text{ k}\Omega}$

Candidate's Response

$\dfrac{I_R}{I_s} = \dfrac{R_s}{R_R}$

$\dfrac{8.5\times10^{-3}}{I_s} = \dfrac{10\times1000}{1000}$

$I_s = 8.5\times10^{-4}$ A

1M
1A

by $V = IR$

$9 = I\ (10\text{k}\Omega)$

$I = 0.9$A

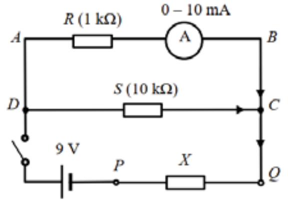
0M
0A

Make sure that when using $V = IR$ the potential difference has to correspond to that resistor.

8. (a) (iii) Indicate on Figure 8.1 the direction of current in each of the three branches via *C*.

MS

(iii)

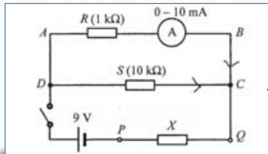


2A
2

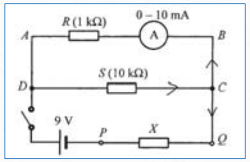
2A for all correct
1A for any TWO correct

Well answered

Candidate's Response



1A
0A



1A
0A

8. (a) (iv) Deduce the p.d. across resistor *X*. Hence, find the resistance of *X*.

MS

(iv) p.d. across $X = 9 - V_{AB} = 9 - 8.5 = 0.5$ V	1M	e.c.f from (a)(i)
Current through $X = (8.5 \times 10^{-3}) + (8.5 \times 10^{-4})$ $= 9.35 \times 10^{-3}$ A	1M	e.c.f from (a)(ii)
Resistance of $X = \dfrac{0.5\text{ V}}{9.35\times10^{-3}\text{ A}}$ $= 53.476\ \Omega \approx 53.5\ \Omega$	1A	
	3	

Candidate's Response

p.d = 9−8.5 = 0.5V

0.5 = (8.5 + 0.85)$\times10^{-3}$ × R

R = 500 Ω

1M
1M
0A

~~$\frac{1}{R_{eq}} = \frac{1}{1\times1000} + \frac{1}{10\times1000}$~~

~~= 909.0909091 Ω~~

Total current = 8.5/1000 + 9×10^{-4}
= 9.4×10^{-3} A

V = IR

0.5 = (9.4×10^{-3})R

R = 53.1914856 Ω ≈ 53.1 Ω

∵ S and R are linked in parallel
∴ voltage distributed should be equal
pd across AD = DC
Pd across DC = 8.5V
Pd across x = 9 − 8.5 = 0.5V

e.c.f.

1M
1M
0A

8. (a) (iv) Deduce the p.d. across resistor *X*. Hence, find the resistance of *X*.

Candidate's Response

p.d. across resistor X = 9 − 8.5
= 0.5 V

By $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ ⇒ $R = \frac{1\times10^3 \times (10\times10^3)}{1\times10^3 + 10\times10^3}$

R = 909.09 Ω

By $V_x = \frac{R_x}{R_x + R} V$ ⇒ $0.5 = \frac{R_x}{R_x + 909.09} \times 9$

R_x = 53.5 Ω

1M
1M
1A

p.d = 9 − 8.5 = 0.5 V

Req of AB and CD = $\frac{1000(10000)}{10000+1000}$ = 909 Ω

0.5 = $9\left(\frac{R}{R+909}\right)$

0.5R + $\frac{909}{0.5}$ = 9R

R = 214 Ω

1M
1M
0A

As simple as possible

8. (b) State the purpose of connecting resistor R in series with the ammeter.

MS			
(b)	To prevent the ammeter from overloading (when PQ is shorted or the resistance to be measured is too small)	1A	Poorly answered
		1	

Candidate's Response

Prevent short circuit. — 0A — Ambiguous

So that the ammeter can measure the current passes through R. — 0A

To ensure the current passing through R is the same as passing through the ammeter. — 0A

Read the question carefully and answer exactly what is asked for

Thanks!

HKDSE PHYSICS BRIEFING SESSION

(4&5 Oct, 2021)

PHYSICS 1B

Q. 2, 5 & 9

QUESTION 2(a)

2. A diver makes a sound by tapping a metal cylinder at sea level. Within a time of 0.04 s, the sound goes vertically to the seabed 30 m below and echoes back to the sea level.

(a) Estimate the speed of sound in sea water. (2 marks)

Marking Scheme	Candidates' Performance
$v = \dfrac{30 \times 2}{0.04}$ 1M $= 1500 \text{ m s}^{-1}$ 1A	Candidates' performance was satisfactory. Quite a number of the candidates did not realise that the sound travelled twice the water depth within the time interval.

QUESTION 2(a) Sample

(a) Estimate the speed of sound in sea water. (2 marks)

$v = \dfrac{30}{0.04}$ ✓✗

$= 750\ \mathrm{m\,s^{-1}}$ ✗

Accept distance travelled = depth of water **1M**
Wrong Answer **0A**

$s = \frac{1}{2}(u+v)t$

$30 = \frac{1}{2}(0+v)(0.04)$ ✗

$v = 1500\ \mathrm{m\,s^{-1}}$ ✗

Wrong equation & wrong distance travelled **0M**
Answer from wrong method **0A**

By $s = ut + \dfrac{1}{2}at^2$

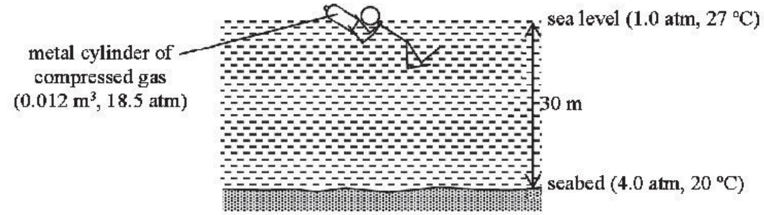
$30 = u(0.04) + \frac{1}{2}(-9.81)(0.04)^2$ ✗

$u = 750.1962$

$\approx 750\ \mathrm{m\,s^{-1}}$ ✗

Wrong equation & wrong distance travelled **0M**
Wrong Answer **0A**

QUESTION 2(b)(i)

Figure 2.1 

The metal cylinder of volume 0.012 m^3 contains compressed gas under a pressure of 18.5 atm is initially at sea level, where the pressure is 1.0 atm and the temperature is 27 °C. The diver then brings the cylinder to the seabed where the pressure is 4.0 atm and the temperature is 20 °C. Assume that the volume of the cylinder remains unchanged. Given: atmospheric pressure 1.0 atm = 1.01×10^5 Pa

*(b)(i) Show that at the seabed the pressure in the cylinder becomes 18.1 atm. (1 mark)

Marking Scheme	Candidates' Performance
$\dfrac{p_1}{T_1} = \dfrac{p_2}{T_2}$ $\dfrac{18.5}{273+27} = \dfrac{p_2}{273+20}$ **1M** $p_2 = 18.068333\ \text{atm} \approx 18.1\ \text{atm}$	Most were able to apply ideal gas equation to answer although a few candidates forgot to add 273 in converting temperature in degree Celsius.

QUESTION 2(b)(i) Sample

*(b)(i) Show that at the seabed the pressure in the cylinder becomes 18.1 atm. (1 mark)

By $\dfrac{P_1}{T_1} = \dfrac{P_2}{T_2}$

$\dfrac{18.5 \times 1.01 \times 10^5}{27+273} = \dfrac{p_2}{20+273}$ ✓

$p_2 = 1824901.667$ Pa

$= 18.0683$ atm

≈ 18.1 atm

Correct equation (pressure expressed in Pa in the calculation) **1M**

$(0.012)18.5 \times 1.01 \times 10^5 = n(8.31)(27+273)$

$n = 8.99$ mol

pressure at the seabed $= \dfrac{\frac{8.99(8.31)(20+273)}{0.012}}{1.01 \times 10^5}$ ✓

$= 18.1$ atm

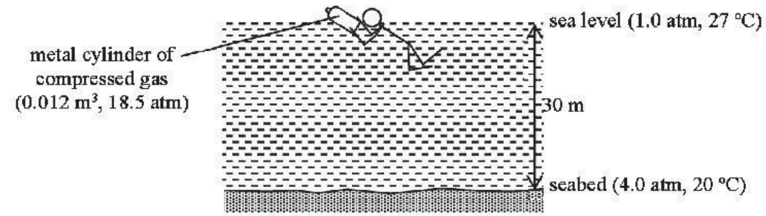
Apply $pV = nRT$ instead of pressure law **1M**

$\dfrac{18.5}{27} = \dfrac{p_2}{20}$ ✗

$p_2 = 18.1$ atm

Did not add 273 to convert the temperature to absolute temperature scale **0M**

QUESTION 2(b)(ii)

Figure 2.1 

The metal cylinder of volume 0.012 m^3 contains compressed gas under a pressure of 18.5 atm is initially at sea level, where the pressure is 1.0 atm and the temperature is 27 °C. The diver then brings the cylinder to the seabed where the pressure is 4.0 atm and the temperature is 20 °C. Assume that the volume of the cylinder remains unchanged. Given: atmospheric pressure 1.0 atm = 1.01×10^5 Pa

*(b)(ii) Explain the pressure drop in the cylinder using the kinetic theory. (2 marks)

Marking Scheme	Candidates' Performance
As the temperature decreases, the speed /kinetic energy of the gas molecules decreases. **1A** They collide less frequently and/or violently with the wall of the container/cylinder. **1A** Thus, the pressure decreases.	A lot of the candidates were competent in using kinetic theory to explain the pressure drop.

QUESTION 2(b)(ii) Sample

(ii) Explain the pressure drop in the cylinder using the kinetic theory. (2 marks)

When the metal cylinder of compressed gas reaches the seabed, the average kinetic energy decreases, ✗ the gas particles collide less frequently with the cylinder wall, ✓ the pressure drops

"Temperature decreases" not mentioned **0A**

Collide less frequently with wall **1A**

As volume remain unchanged, the temperature decrease so the gas molecules moves slower ✓ in the cylinder and collision decrease. ✗ Therefore pressure drop.

Temperature decreases and molecules move slower **1A**

"Collison with wall/cylinder" not mentioned **0A**

∵ Temperature decreases

∴ Internal energy of gas molecules decreases

∴ Speed of molecules decreases ✓

∴ By $pV = \frac{1}{2}Nm\overline{c^2}$ ✗

∵ $\overline{c^2}$ decreases, V constant

∴ p decreases

Temperature decreases, speed decreases **1A**

Use kinetic theory equation to explain pressure drop **0A**

QUESTION 2(b)(ii) Sample

(ii) Explain the pressure drop in the cylinder using the kinetic theory. (2 marks)

As the volume and mass of the cylinder stay constant, the pressure is directly proportional to the temperature in Kelvin of the cylinder. ✗ Therefore, as the temperature of the cylinder drops, the pressure drops too. ✗

Use gas law to explain **0A 0A**

QUESTION 2(c)(i)

*(c) The diver then inflates identical balloons each to a volume of 0.015 m³ by using the cylinder of compressed gas at the seabed. Assume that the balloons are inflated slowly so that the temperature of the gas remains unchanged and the final pressure in the balloon equals that at the seabed.

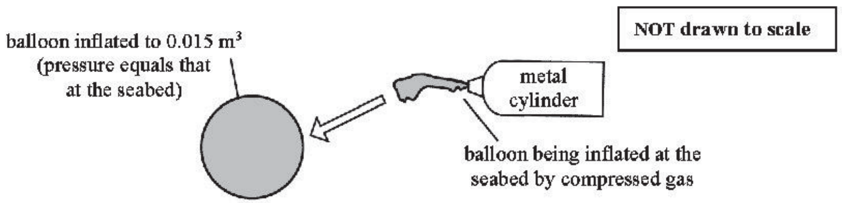


Figure 2.2

(i) Show that the gas pressure in the cylinder decreases by 5.0 atm after inflating one balloon. (2 marks)

Marking Scheme	Candidates' Performance
$n_0 = n_1 + n_2$ **1M** $p_0V_0 = p_1V_1 + p_2V_2$ $18.1 \times 0.012 = p_1 \times 0.012 + 4 \times 0.015$ **1M** $p_1 = 13.1$ atm (i.e. $\Delta p = 5.0$ atm)	Candidates employed different approaches including mole ratio or pressure ratio.

QUESTION 2(c)(i) Sample

(i) Show that the gas pressure in the cylinder decreases by 5.0 atm after inflating one balloon. (2 marks)

By $pV = nRT$

Change in no. of moles of gas $= \dfrac{4\times0.015}{RT}$

Change in pressure $= \dfrac{\frac{4\times0.015}{RT}\times RT}{0.012} = 5$ atm ✓✓

Correct method ($\Delta p = \Delta n\dfrac{RT}{V}$) **1M**

Correct substitution of values **1M**

no. of mol of gas in cylinder before inflating a balloon

$= \dfrac{18.1\times1.01\times10^5\times0.012}{RT} = \dfrac{21937}{RT}$

no. of mol of gas after inflating one balloon

$= \dfrac{21937}{RT} - \dfrac{4\times1.01\times10^5\times0.015}{RT} = \dfrac{15877}{RT}$

$p_2 = \dfrac{15877}{21937} \times 18.1 = 13.1$ atm ✓✓

decrease in pressure = 18.1 – 13.1 = 5 atm

Correct method ($\dfrac{p'}{p} = \dfrac{n'}{n}$) **1M**

Correct substitution of values **1M**

QUESTION 2(c)(i) Sample

(i) Show that the gas pressure in the cylinder decreases by 5.0 atm after inflating one balloon. (2 marks)

for 1 balloon,

$4\times1.01\times10^5\times0.015 \div (20+273) = nR = 20.6826$

for the cylinder originally,

$18.5\times1.01\times10^5\times0.012 \div (27+273) = n'R = 74.74$

for cylinder after inflating 1 balloon,

$p\times1.01\times10^5\times0.012 = (74.74 - 20.6828)(20+273)$ ✓✓

$p = 13.0683$ atm

decrease in gas pressure $= 18.0683 - 13.0683$

$= 5.0$ atm

Correct method ($p'V = n'RT$) 1M

Correct substitution of values 1M

$p_1 V_1 = p_2 V_2$

$0.012(18.5\times1.01\times10^5) = 0.012p + 0.015(4\times1.01\times10^5)$ ✗

$\frac{p}{1.01\times10^5} = 13.5$

$p = 13.5$ atm

decrease in gas pressure in cylinder $= 18.5 - 13.5$

$= 5$ atm

Wrong equation – should divide pV by RT (or T) OR use the initial pressure of gas in the cylinder at the seabed (so that the temperatures are the same) 0M

Substitution into wrong equation 0M

QUESTION 2(c)(i) Sample

(i) Show that the gas pressure in the cylinder decreases by 5.0 atm after inflating one balloon. (2 marks)

$\because$ gas temperature remains unchanged, by Boyle's law.

Let x be the pressure change

$(18.1 - x)(0.012) = 18.1(0.015)$ ✗

$(0.012)(18.1 - x) = 0.2715$

$x = -5.0$ atm

Incorrect application of Boyle's law -- final pV of cylinder is not equal to pV of balloon & wrong pressure of balloon 0M 0M

$(0.012)(18.068) = (0.012+0.015)p$ ✗

$0.216816 = 0.027p$

$p = 8.030$ atm

$\therefore$ The decrease in pressure is 18.068 -

Incorrect application of Boyle's law -- final pressures of gas in the cylinder and in the balloon are different 0M 0M

By Boyle's law

$p_1 V_1 = p_2 V_2$

$4 \times 0.015 = p_2 \times 0.012$ ✗

$p_2 = 5$ atm

p_2 calculated is the pressure of gas in the balloon when the volume is reduced to 0.012 m^3 0M 0M

QUESTION 2(c)(ii)

*(c) The diver then inflates identical balloons each to a volume of 0.015 m^3 by using the cylinder of compressed gas at the seabed. Assume that the balloons are inflated slowly so that the temperature of the gas remains unchanged and the final pressure in the balloon equals that at the seabed.

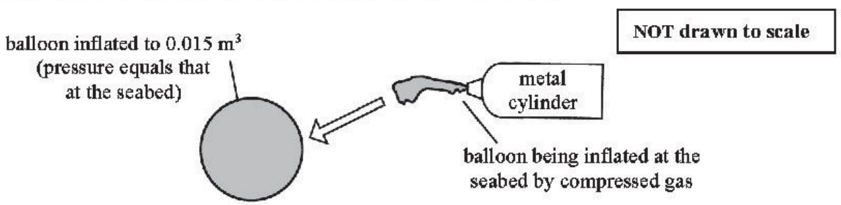


Figure 2.2

(ii) Hence, find the total number of balloons that the diver can inflate completely. (2 marks)

Marking Scheme	Candidates' Performance
The pressure decreases by 5.0 atm for inflating one balloon. assume k balloons can be inflated completely: $18.1 - 5.0k \geq 4.0$ or $k \leq \frac{18.1-4.0}{5.0} = 2.82$ 1M $\therefore k = 2$ 1A OR $18.1 \times 0.012 = 4 \times V$, $V = 0.0543$ m^3 $0.0543 - 0.015\times k \geq 0.012$ $k \leq 2.82$ $\therefore k = 2$	Quite a number of candidates did not realise that the pressure of compressed gas needed to be greater than the pressure outside, i.e. 4.0 atm at the seabed.

QUESTION 2(c)(ii) Sample

(ii) Hence, find the total number of balloons that the diver can inflate completely. (2 marks)

$\frac{18.1}{5} = 3.62$ ✓

Total 3 balloons (including the balloon in (i)) can inflate completely. ✗

Accept neglecting the final pressure of cylinder. 1M

Wrong answer 0A

Let n be total number of balloons diver can inflate completely,

$5n \leq 18.5$ ✗

$n \leq 3.7$

$\therefore$ total number of balloons diver can inflate completely is 3. ✗

Wrong initial pressure of cylinder & neglecting the final pressure of cylinder. 0M

Wrong answer 0A

$\frac{\frac{(18.1)(0.012)}{8.31(273+20)}}{\frac{5(0.015)}{8.31(273+20)}} \approx 2.896$ ✗

$\therefore$ total number is 2. ✗

Wrong pressure of balloons & neglecting the final pressure of cylinder. 0M

Answer from wrong equation 0A

QUESTION 5(a)(i)

5. A rocket carrying an artificial satellite is launched vertically from the Earth. When the rocket is at a certain height from the Earth's surface, it expels 2.60×10^3 kg of gas per second with a certain speed v towards the Earth's centre. As a result, an average thrust of 5.20×10^6 N is produced. Neglect air resistance.

(a) (i) Assuming that the speed of the rocket is negligible, estimate v. (2 marks)

Marking Scheme	Candidates' Performance
$F = \frac{\Delta p}{\Delta t} = \frac{2.60 \times 10^3 \times v}{1} = 5.20 \times 10^6$ 1M $v = 2000 \text{ m s}^{-1}$ 1A	Candidates' performance was fair in general. Some candidates failed to relate the average thrust to the rate of change of momentum of the exhaust gas

QUESTION 5(a)(i) Sample

(a) (i) Assuming that the speed of the rocket is negligible, estimate v. (2 marks)

$F = ma$

$5.2\text{x}10^6 = (2.6\text{x}10^3)a$ ✗

$a = 2000 \text{ m/s}^2$

$v = u + at$

$v = 2000 \text{ m/s}$ ✗

Assuming the gas expelled are accelerated uniformly from rest for 1 sec **0M**

Answer from wrong method **0A**

$F = ma$

$F = \frac{m(v-u)}{t}$

$5.20\text{x}10^6 = \frac{2.60\text{x}10^3(v-0)}{1}$ ✓

$v = 2000 \text{ m s}^{-1}$ ✓

Correct equation (the candidate did not apply $F = ma$ to calculate a and use a to find v) **1M**

Correct answer **1A**

$v = \frac{F}{m}$ ✗

$= \frac{5.20\text{x}10^6}{2.60\text{x}10^3}$

$= 2000 \text{ m s}^{-1}$ ✗

Wrong equation **0M**

Answer from wrong method **0A**

QUESTION 5(a)(i) Sample

(a) (i) Assuming that the speed of the rocket is negligible, estimate v. (2 marks)

$P = \frac{E}{t} = Fv$

$\frac{1}{2}(2.6\text{x}10^3)v^2 = (5.2\text{x}10^6)v$ ✗

$v = 4000 \text{ m s}^{-1}$ ✗

Thrust × ejected velocity of gas is not equal to the increase of KE of gas per sec **0M**

Wrong answer **0A**

QUESTION 5(a)(ii)

5. A rocket carrying an artificial satellite is launched vertically from the Earth. When the rocket is at a certain height from the Earth's surface, it expels 2.60×10^3 kg of gas per second with a certain speed v towards the Earth's centre. As a result, an average thrust of 5.20×10^6 N is produced. Neglect air resistance.

(a) (ii) At a certain instant, the total mass of the rocket and the artificial satellite is 3.60×10^5 kg while the acceleration due to gravity at the rocket's position is 8.56 m s^{-2}. Estimate the acceleration a of the rocket at this position. (2 marks)

Marking Scheme	Candidates' Performance
$F - mg = ma$ $a = \frac{F}{m} - g = \frac{5.2\times10^6}{3.6\times10^5} - 8.56$ 1M $= 5.884444 \text{ m s}^{-2} \approx 5.88 \text{ m s}^{-2}$ 1A	In applying Newton's laws of motion to find the rocket's acceleration, weaker candidates omitted the weight mg or wrongly took the net force as $F_{\text{thrust}} + mg$.

QUESTION 5(a)(ii) Sample

(ii) At a certain instant, the total mass of the rocket and the artificial satellite is 3.60×10^5 kg while the acceleration due to gravity at the rocket's position is 8.56 m s^{-2}. Estimate the acceleration a of the rocket at this position. (2 marks)

$F = ma$ $5.2 \times 10^6 = 3.6 \times 10^5 a$ ✗ $a = 14.4 \text{ m s}^{-2}$ ✗	Weight of rocket & satellite not considered 0M Wrong answer 0A
$a = \dfrac{5.20 \times 10^6 + 3.6 \times 10^5 \times 8.56}{3.6 \times 10^5}$ ✗ $= 124 \text{ m s}^{-2}$ ✗	Net force = Thrust + mg 0M Wrong answer 0A
$F = ma - mg$ $5.2 \times 10^6 = 3.6 \times 10^5 (a - 8.56)$ ✗ $a \approx 23.004$ $\approx 23.0 \text{ m s}^{-2}$ ✗	Thrust = $m(a - g)$ 0M Wrong answer 0A
$F = ma$ $3.6 \times 10^5 (9.81 - 8.56) = 3.6 \times 10^5 a$ ✗ $a = 1.25 \text{ m s}^{-2}$ ✗	Net force = $m(g_0 - g)$ 0M Wrong answer 0A

QUESTION 5(a)(iii)

5. A rocket carrying an artificial satellite is launched vertically from the Earth. When the rocket is at a certain height from the Earth's surface, it expels 2.60×10^3 kg of gas per second with a certain speed v towards the Earth's centre. As a result, an average thrust of 5.20×10^6 N is produced. Neglect air resistance.

(a) (iii) Suppose the rocket keeps expelling gas at the same rate for a few seconds. Would the rocket's acceleration increase, decrease or remain unchanged in that duration ? Explain. (2 marks)

Marking Scheme	Candidates' Performance
The acceleration would increase. 1A Although the thrust remains the same, the mass of the rocket and/or g decreases. 1A	Candidates performed poorly. Not many were able to point out that the average thrust remained the same while the rocket's mass decreased.

QUESTION 5(a)(iii) Sample

(iii) Suppose the rocket keeps expelling gas at the same rate for a few seconds. Would the rocket's acceleration increase, decrease or remain unchanged in that duration ? Explain. (2 marks)

As the rocket keeps expelling gas, the mass of it will decrease. The gas is kept expelling at a constant rate, the thrust will be constant. ✓ By Newton's 2nd law of motion, the acceleration will increase. ✓	Increase 1A Constant thrust & mass decreases (without "g decreases" accepted) 1A
Increase ✓ as the acceleration due to gravity is lower as the rocket goes further, the weight of the rocket will decrease and so the acceleration of the rocket increase. ✗	Increase 1A Constant thrust not mentioned 0A
Increase ✓ when the distance between the rocket and the Earth increase, the gravitational force act on the ✗ rocket decrease, so the acceleration will increase.	Increase 1A Constant thrust not mentioned 0A

QUESTION 5(a)(iii) Sample

(iii) Suppose the rocket keeps expelling gas at the same rate for a few seconds. Would the rocket's acceleration increase, decrease or remain unchanged in that duration ? Explain. (2 marks)

Acceleration will increase ✓ As it moves away from the earth, the acceleration due to gravity ✗ decrease while acceleration due to expelling gas is the same. The resultant acceleration will increase.	Increase 1A Acceleration due to expelling gas is the same 0A
The rockets acceleration increase ✓ as rocket keeps expelling gas and by newton 3rd law of motion, the gas provide a force to put the rocket and accelerate ✗	Increase 1A Force does not cause acceleration to increase 0A
Increase ✓ Since the mass of rocket decreases and the net force remains unchanged ✗ $a = F/m$ increases.	Increase 1A Net force increases NOT remains unchanged 0A

QUESTION 5(b)(i)

*(b) The artificial satellite is put in the geostationary orbit of radius r around the Earth. It appears to be always stationary above an observer at the equator.

(i) State the period of this satellite. (1 mark)

Marking Scheme	Candidates' Performance
24 hours / 1 day / 86400 s **1A**	A few candidates mistook the period of the satellite around the Earth as 1 year or 365 days

QUESTION 5(b)(i) Sample

(i) State the period of this satellite. (1 mark)

365 days — Wrong period **0A**

The time to make one complete revolution — Definition of period not accepted **0A**

$T = \frac{2\pi}{\omega}$ — Equation for period not accepted **0A**

$T = \frac{2\pi r}{v}$ — Equation for period not accepted **0A**

QUESTION 5(b)(ii)

*(b) The artificial satellite is put in the geostationary orbit of radius r around the Earth. It appears to be always stationary above an observer at the equator.

(ii) Show that r is approximately 42000 km. ($g = 9.81\ \text{m s}^{-2}$) (2 marks)
Given: radius of the Earth = 6.37×10^6 m

Marking Scheme	Candidates' Performance
$(m\omega^2 r = \frac{GMm}{r^2}$ or $\frac{mv^2}{r} = \frac{GMm}{r^2})$ and $(\omega = \frac{2\pi}{T}$ or $v = \frac{2\pi r}{T})$ **1M** OR $gR^2 = v^2 r = (\frac{2\pi r}{T})^2 r$ $r^3 = \frac{GM}{R^2} \times R^2 \times \frac{1}{\omega^2}$ $= 9.81 \times (6.37 \times 10^6)^2 \times (\frac{24 \times 60 \times 60}{2\pi})^2$ **1M** $r = 4.222197 \times 10^7\ \text{m} \approx 42000\ \text{km}$	Only the more able ones knew how to make use of $\frac{GM}{R^2} = g$ to tackle this part.

QUESTION 5(b)(ii) Sample

(ii) Show that r is approximately 42000 km. ($g = 9.81\ \text{m s}^{-2}$) (2 marks)
Given: radius of the Earth = 6.37×10^6 m

$g_0 r_0^2 = g_1 r_1^2$

$9.81(6.37\times10^6)^2 = r_1 (\frac{2\pi}{86400})^2 r_1^2$

$r_1 = 42.2\times10^6$ m

$= 42222$ km

≈ 42000 km

$g_0 r_0^2 = g_1 r_1^2$ & $g_1 = r_1 (\frac{2\pi}{86400})^2$ **1M**
Correct substitution **1M**

$mg = \frac{GMm}{r^2}$

$9.81 = \frac{GM}{r^2}$

$M = 5.96447\times10^{24}$ kg

$m\omega^2 r = \frac{GMm}{r^2}$

$\frac{4\pi^2}{(86400)^2} = \frac{G(5.96447\times10^{24})}{(6.37\times10^6 + r)^3}$

$m\omega^2 r = \frac{GMm}{r^2}$ & $\omega = \frac{2\pi}{T}$ **1M**
radius $= 6.37 \times 10^6 + r$ **0M**

QUESTION 5(b)(ii) Sample

(ii) Show that r is approximately 42000 km. ($g = 9.81$ m s^{-2}) (2 marks)
Given: radius of the Earth = 6.37×10^6 m

$$\frac{GMm}{r^2} = mr\omega^2$$
$$\frac{GM}{r^3} = \left(\frac{2\pi}{T}\right)^2 \checkmark$$
$$\frac{GM}{r^2}\left(\frac{1}{r}\right) = \left(\frac{2\pi}{T}\right)^2$$
$$\frac{g}{r} = \left(\frac{2\pi}{T}\right)^2 \times$$
$$\frac{9.81}{6.37\times10^6} = \frac{4\pi^2}{T^2}$$
$$T = 5060 \text{ s}$$

$\frac{GMm}{r^2} = mr\omega^2$ & $\omega = \frac{2\pi}{T}$ **1M**
$GM = gr^2$ **0M**

$$T^2 = \left(\frac{4\pi^2}{GM}\right)r^3 \checkmark$$
$$(24 \times 3600)^2 = \frac{4\pi^2}{gR^2}r^3 \times$$
$$r = 42000 \text{ km}$$

Correct equation relating r and T **1M**
No substitution of g and R **0M**

QUESTION 5(b)(ii) Sample

(ii) Show that r is approximately 42000 km. ($g = 9.81$ m s^{-2}) (2 marks)
Given: radius of the Earth = 6.37×10^6 m

$$r'\omega^2 = 9.81 \times$$
$$r'\left(\frac{2\pi}{T}\right)^2 = 9.81$$
$$r' = 9.81 \div \left(\frac{2\pi}{86400}\right)^2$$
$$r' = 1.85\times10^9 \text{ m}$$
$$r = 1.85\times10^9 + 6.375\times10^6$$
$$= 1860000 \text{ km} \times$$

$r\omega^2 = g_0$ **0M**
Wrong answer **0M**

$$a = \frac{v^2}{r} = \omega^2 r$$
$$a = \frac{v^2}{42000} = \omega^2(42000) \times$$
$$F = ma = \frac{GMm}{r^2}$$
$$a = \frac{GM}{(42000)^2}$$

Unable to obtain an equation relating r with T **0M**
No numerical values for ω and GM **0M**

QUESTION 9(a)(i)

9. Potassium-40 ($^{40}_{19}$K) is a natural radioisotope of potassium.

(a) (i) What kind of decay does $^{40}_{19}$K undergo if it decays to $^{40}_{20}$Ca ? (1 mark)

Marking Scheme	Candidates' Performance
β decay / beta decay **1A** OR $^{40}_{19}\text{K} \rightarrow ^{40}_{20}\text{Ca} + ^{0}_{-1}\beta$	The performance of candidates was good, most candidates knew that β decay occurred.

QUESTION 9(a)(i) Sample

(a) (i) What kind of decay does $^{40}_{19}$K undergo if it decays to $^{40}_{20}$Ca ? (1 mark)

Electron ✗ — "Electron" not accepted **0A**

Nuclear fission ✗ — Wrong answer **0A**

gamma ✗ — Wrong answer **0A**

QUESTION 9(a)(ii)

9. Potassium-40 ($^{40}_{19}K$) is a natural radioisotope of potassium.

(a) (ii) As banana is rich in potassium, a student claims that the radiation emitted by $^{40}_{19}K$ after eating a few bananas can be detected outside the human body. Explain whether this claim is justified. (1 mark)

Marking Scheme	Candidates' Performance
Justified: the penetrating power of beta radiation enables it to penetrate body's organ/skin. 1A OR Not justified: the activity is low and is comparable to background radiation / β radiation is (largely) shielded by the human body	Candidates' performance was fair. Some explained in terms of ionizing power or range of β particles instead of penetrating power.

QUESTION 9(a)(ii) Sample

(ii) As banana is rich in potassium, a student claims that the radiation emitted by $^{40}_{19}K$ after eating a few bananas can be detected outside the human body. Explain whether this claim is justified. (1 mark)

No. β particle is blocked by 5 mm aluminium. Thus β particle cannot be detected outside the human body.

"blocked by aluminium" does not imply "blocked by human body" 0A

No, as occurrence of decay is slow, radiation would not be detected even after the potassium in banana is ? ? the human body.

"decay is slow" not accepted 0A

As potassium-40 undergoes β decay, β particle Is emitted. As β particle is too large to pass through human body, radiation emitted will not be detected outside the human body. The claim is not justified.

"β particle too large" not accepted 0A

QUESTION 9(a)(ii) Sample

(ii) As banana is rich in potassium, a student claims that the radiation emitted by $^{40}_{19}K$ after eating a few bananas can be detected outside the human body. Explain whether this claim is justified. (1 mark)

$\because$ $^{40}_{19}K$ has a long half-life
$^{40}_{19}K$ will not decay immediately after been eaten
$\therefore$ No

"long half-life" not accepted 0A

No. As is very stable and less likely to undergo decays.

"very stable" not accepted 0A

Beta particle has high ionization power, they can can be detected outside the human body.

"high ionization power" does not imply high penetrating power 0A

QUESTION 9(b)(i)

*(b) A banana typically contains 0.45 g potassium in which 0.012% by mass is $^{40}_{19}K$ while the rest is $^{39}_{19}K$.

Given: half-life of $^{40}_{19}K = 1.25 \times 10^9$ years
1 year = 3.16×10^7 seconds
molar mass of $^{40}_{19}K$ = 40.0 g

(i) Estimate the number of moles of $^{40}_{19}K$ in a banana. (1 mark)

Marking Scheme	Candidates' Performance
$\frac{0.45 \times 0.012\%}{40.0} = 1.35 \times 10^{-6}$ (mole) 1A	Well answered. Some candidates forgot to multiply 0.012% or multiplied 0.012 instead of 0.012% .

QUESTION 9(b)(i) Sample

(i) Estimate the number of moles of $^{40}_{19}K$ in a banana. (1 mark)

Mass of $^{40}_{19}K$ in banana $= 0.012\% \times 0.45$
$= 5.4\times10^{-3}$ g

No. of moles of $^{40}_{19}K$ in banana $= \dfrac{5.4\times10^{-3}}{40}$
$= 1.35\times10^{-4}$ mole ✗

Wrong answer -- multiplied 0.012 instead of 0.012% **0A**

$0.45 \times 0.012\% = 5.4\times10^{-5}$ ✗

Wrong answer – mass of $^{40}_{19}K$ was calculated **0A**

No. of mole $= \dfrac{0.45}{40} = 0.01125$ ✗

Wrong answer – no. of moles of potassium was calculated **0A**

$\dfrac{0.45\times0.012\%}{40} \times (6.02\times10^{23}) = 8.127\times10^{17}$ mol ✗

Wrong answer – number of $^{40}_{19}K$ was calculated **0A**

QUESTION 9(b)(ii)

*(b) A banana typically contains 0.45 g potassium in which 0.012% by mass is $^{40}_{19}K$ while the rest is $^{39}_{19}K$.
Given: half-life of $^{40}_{19}K = 1.25 \times 10^9$ years
1 year $= 3.16 \times 10^7$ seconds
molar mass of $^{40}_{19}K = 40.0$ g

(ii) Deduce the activity, in Bq, of a banana. (2 marks)

Marking Scheme	Candidates' Performance
$k = \dfrac{\ln 2}{1.25 \times 10^9\ (3.16 \times 10^7)}$ **1M/1A** $= 1.754803 \times 10^{-17}\ s^{-1}$ Activity $= kN$ $= 1.754803 \times 10^{-17}$ $\times (1.35 \times 10^{-6} \times 6.02 \times 10^{23})$ $= 14.261284$ (Bq) ≈ 14.3 Bq **1A**	Many candidates knew how to tackle this part. However, quite a number of them made mistakes in units conversion or mistook N as the number of moles of radioactive nuclides.

QUESTION 9(b)(ii) Sample

(ii) Deduce the activity, in Bq, of a banana. (2 marks)

$\dfrac{ln2}{k} = t_{½} = (1.25\times10^9)(3.16\times10^7)$ ✓
$k = 1.45\times10^{-17}$
$A = Nk$
$= \left(\dfrac{0.45\times12}{1000}\right)(1.45\ \times10^{-17})$
$= 7.90\times10^{-21}$ Bq ✗

Correct method to find k **1M**

Wrong answer – wrong N and wrong k **0A**

$k = \dfrac{ln2}{1.25\times10^9} = 5.545\times10^{-10}$ ✓
Activity $= 5.545\times10^{-10} \times (1.35\times10^{-6})(6.02\times10^{23})$
$= 4.506\times10^{20}$ Bq ✗

Correct method to find k (in year^{-1}) **1M/1A**

Wrong answer – k is not in s^{-1} **0A**

$A = kN$
$= \dfrac{ln2}{t_{½}}(N)$ ✓
$= 1.75\cdot10^{-17}(1.35\cdot10^{-4})$
$= 2.36\cdot10^{-21}$ Bq ✗

Correct value of k **1M/1A**

Wrong answer – wrong N **0A**

Thank You!

Paper 2

Section A: Astronomy and Space Science

Q.1 Multiple-choice questions

	A	B	C	D
1.1	8.6	54.3*	17.5	19.6
1.2	13.9	52.6*	15.2	18.3
1.3	18.9	14.4	13.8	52.9*
1.4	8.0	8.7	62.7*	20.6
1.5	46.2*	14.0	13.1	26.7
1.6	17.8	14.7	22.5	45.0*
1.7	39.2*	22.6	21.0	17.2
1.8	16.9	19.4	28.6	35.1*

*** : key** ; Red colour : most favourable distractor

MCQ 1.5

Stars X and Y are of equal apparent brightness. Parallax of star X is twice that of star Y. What is the ratio $\frac{\text{luminosity of star } X}{\text{luminosity of star } Y}$?

$\boxed{\text{*A. } \frac{1}{4}}$ 46.2%

B. $\frac{1}{2}$

C. 2

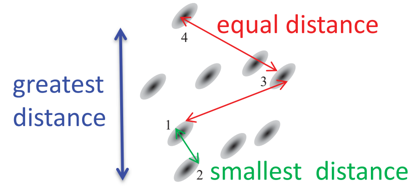
$\boxed{\text{D. } 4 \text{ favourable distractor}}$ 26.7%

distance of a star $\propto \frac{1}{\text{parallax}}$, Twice of parallax $\Rightarrow$ distance / 2

Luminosity = $4\pi R^2 \sigma T^4$, $\frac{L_X}{L_Y} = \frac{1}{4}$

MCQ 1.6

The figure shows a snapshot of a group of galaxies.



A. (1) only

B. (1) and (3) only

$\boxed{\text{C. (2) and (3) only}}$ favourable distractor 22.5%

$\boxed{\text{*D. (1), (2) and (3)}}$ 45.0%

Which of the following statements is/are correct ?

(1) For observers in Galaxy 1, the absorption lines of Galaxy 4 shows a greater red shift than those of Galaxy 2.

(2) For observers in Galaxy 2, Galaxy 4 is moving away at a higher speed than Galaxy 1 is.

(3) For observers in Galaxy 3, Galaxy 1 and Galaxy 4 are moving away at roughly the same speed.

Hubble's law: the recession velocity of a galaxy is directly proportional to its distance

MCQ 1.7

What information of a star can be deduced from its absorption spectrum ?

(1) its spectral class

(2) its radial velocity

(3) the chemical composition of its core

*A. (1) and (2) only 39.2%

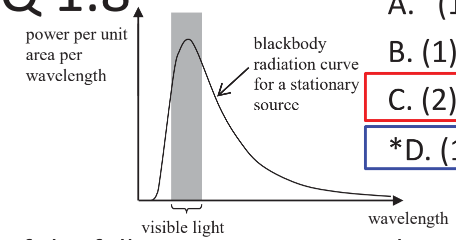
B. (1) and (3) only favourable distractor 22.6%

C. (2) and (3) only

D. (1), (2) and (3)

The chemical composition of the **surface** of the star.

MCQ 1.8



A. (1) only

B. (1) and (3) only

C. (2) and (3) only favourable distractor 28.6%

*D. (1), (2) and (3) 35.1%

Which of the following statements about the Doppler shift of the blackbody radiation from a source moving away from the Earth is/are correct ?

(1) The peak of the blackbody radiation curve observed shifts to the right.

(2) The temperature of the source inferred from the observation is cooler than the actual value.

(3) The colour of the source observed looks different from that of a stationary source.

The star moving away from Earth shows red shift ⇒ longer wavelength

The colour of the source inferred from observation is more red, i.e. cooler than the actual situation.

Q.1 Structured question

In our galaxy, there is a strong radio wave emitting source known as Sgr A* which is located at a distance 7940 pc away from the Earth. A star *X* is found orbiting around Sgr A* in an elliptical orbit with a period of 16.0 years.

(a) (i) The semi-major axis of the orbit, *a*, of star *X* is known to have an angular size of 0.125″. Determine the value of *a* in units of AU. (1 mark)

angular size $\theta = 0.125'' = \frac{0.125}{60\times60} \times \frac{\pi}{180^\circ} = 6.06\times10^{-7}$ rad

$a = d \times \theta = 7940 \times 206265 \times 6.06\times10^{-7} = 992.5$ AU

Or By definition: 1″ = 1 AU/1 pc

Hence, the semi-major axis

a = 0.125″ × 7940 pc = 992.5 AU ≈ 993 AU (991 ~ 994)

Revealed that many candidates did not fully understand the concepts of parsec and angular size. Quite a number of them were not aware that the angle must be in radian when calculating the angular size.

1(a)(i). $a = \frac{1}{0.125''}$

$= 8$ Au ✗

a(i) $\tan\left(\frac{0.125}{3600}\right) = \frac{a}{7940}$

$a = 4.81177\times10^{-3}$ pc

$a = 992.5$ AU ✓

$a = 993$ AU

(ii) Hence use Kepler's third law for elliptical orbits, $T^2 = \frac{4\pi^2 a^3}{GM}$, to show that the mass of Sgr A* is about 3.82×10^6 times the mass of the Sun. (2 marks)

Consider the Earth and the Sun, we have
$a = 1$ AU, $M = M_S$ and $T = 1$ year

$$\frac{M_{SgrA*}}{M_S} = \frac{\left(\frac{993\ \text{AU}}{1\ \text{AU}}\right)^3}{\left(\frac{16.0\ \text{yr}}{1\ \text{yr}}\right)^2} = 3.819017 \times 10^6 \approx 3.82 \times 10^6$$

1 M : Compare the two systems using Kepler's third law.

1M : Correct substitution (0 M if a(i) is incorrect)

b. As shown in Figure 1.1, an observer on Earth is aligned with the semi-major axis of the elliptical orbit *ABCD* of star *X*. The variation of the radial velocity v_r of *X* along the line of sight is shown in the graph below: v_r is taken to be positive for an object receding from the observer while a negative v_r implies an approaching object. The possible locations of Sgr A* are positions 1 or 2.

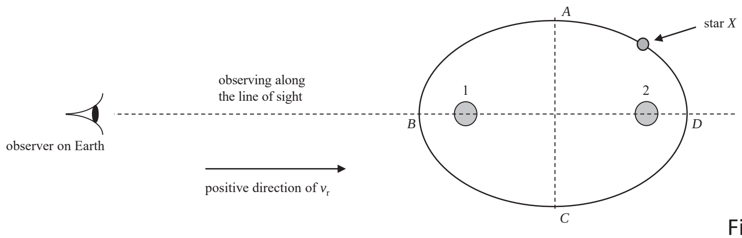
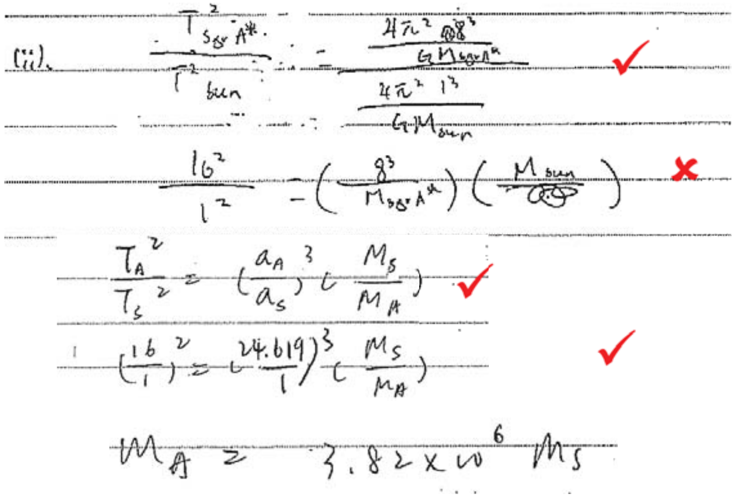


Figure 1.1

In (a)(ii), most candidates were able to start with Kepler's third law but less able ones failed to compare the Sgr A*-*X* and Sun-Earth systems in order to find the mass of Sgr A*.



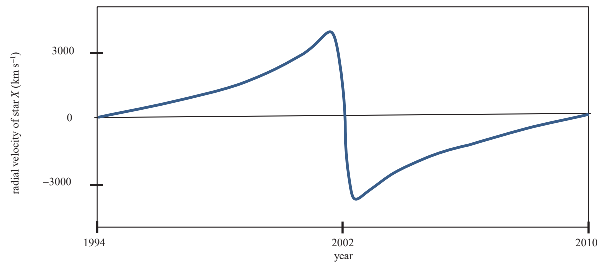
$$\text{(ii)}\quad \frac{T^2_{Sgr A*}}{T^2_{Sun}} = \frac{\frac{4\pi^2 \cdot 8^3}{GM_{SgrA*}}}{\frac{4\pi^2 1^3}{GM_{Sun}}}$$

$$\frac{16^2}{1^2} = \left(\frac{8^3}{M_{SgrA*}}\right)\left(\frac{M_{Sun}}{\cancel{}}\right)$$

$$\frac{T_A^2}{T_S^2} = \left(\frac{a_A}{a_S}\right)^3\left(\frac{M_S}{M_A}\right)$$

$$\left(\frac{16}{1}\right)^2 = \left(\frac{24.619}{1}\right)^3\left(\frac{M_S}{M_A}\right)$$

$$M_A = 3.82 \times 10^6\ M_S$$



(i) Give one method to determine v_r. State the difference in observation for positive and negative values of v_r in your proposed method. (2 marks)

Radial velocity v_r: measured by Doppler shift of spectral lines (emission / absorption lines) of star *X*. 1A

For positive v_r, the observed wavelength of the spectral features will be redshifted (larger wavelength or lower frequency) or blue shift (shorter wavelength or higher frequency) for negative v_r. 1A

In (b)(i), candidates knew that the radial velocity could be deduced using the Doppler effect.

(b) (i) ① 测量从恒星X发出的光线的多普勒平移来计算 V_r，当 V_r 为正时，光谱线会发生红移，~~[illegible]~~
② 波长变长，而当 V_r 为负时，谱线会蓝移，波长变短。

b)(i) Measure Doppler shift. Difference between positive and negative values of v_r represent opposite direction.

b(ii) State where star X is located, A, B, C or D, around the year 2002. Hence determine the location of Sgr A* (position 1 or position 2). Explain your choice. (2 marks)

At position D (around 2002). 1A

Sgr*A at position 2

In 2002, v_r of X changed from a large positive value to a large negative value, indicating that it was affected by a great gravitational force.

Accept: X moves faster when it is closer to the Sgr A*. 1A

In (b)(ii), most knew that star X was at D around the year 2002. However, few could correctly explain the fact that Sgr A* is at position 2.

Some candidates confused radial velocity and orbital speed.

(ii) ~~D~~ D, Position 2 Since before and after ~~2002~~ D, the speed is maximum.

(ii) A. Sgr A* is located at position 2. It is because the velocity is decreasing when star X move from A to B.

(c) For a spherical celestial body of mass M and radius R, the escape velocity from its surface is given by $v = \sqrt{\frac{2GM}{R}}$

where G is the universal gravitational constant. Scientists believe that Sgr A* is a black hole, which is supposed to have an extremely strong gravitational field on its surface that even light cannot escape. Using the above equation and the result of (a)(ii), estimate the radius of this black hole (assume spherical mass distribution) in units of AU. Given: $GM_S = 1.33 \times 10^{20}$ N m^2 kg^{-1}, where M_S is the mass of the Sun. (3 marks)

(c) As escape velocity $v = \sqrt{\frac{2GM}{R}}$,		
we have $R = \frac{2GM}{v^2}$.		
Setting v as the speed of light c, radius of black hole	1M	Taking escape velocity = speed of light
$R_{BH} = \frac{2GM_{SgrA^*}}{c^2}$		
$R_{BH} = \left(\frac{2(1.33\times10^{20}\times3.82\times10^{6})}{(3\times10^{8})^2}\right)$	1M	Correct substitution: $GM_s \times 3.82\times10^6$
$= 1.129022 \times 10^{10}$ m $\approx 1.13 \times 10^{10}$ m		
≈ 0.0752681 (AU) ≈ 0.075 (AU) (NOT accept in metres)	1A	
	3	

In (c), a considerable number of candidates mistakenly used the radial velocity as the escape velocity to calculate the radius of the black hole.

1c. $V = \sqrt{\frac{2GM}{R}}$

$\infty = \sqrt{\frac{2(1.33\times10^{20})(3.82\times10^{6})}{R}}$

∴ R tends to infinity

∴ The radius is infinite.

(c). $v = \sqrt{\frac{2GM}{r}}$

$(3000\times1000)^2 = \frac{2\cdot1.33\times10^{20}}{r}$

$r = 2.96\times10^{7}$ m

Paper 2

Section C : Energy and Use of Energy

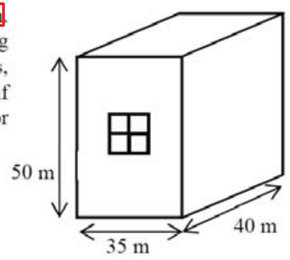
Q.3 Multiple-choice questions

	A	B	C	D
3.1	4.7	19.0	**72.8***	3.2
3.2	9.4	5.3	23.8	**61.4***
3.3	25.4	**65.8***	5.8	2.9
3.4	10.1	21.2	**48.5***	19.2
3.5	**55.0***	14.4	14.0	16.5
3.6	6.7	13.8	**73.5***	5.8
3.7	5.4	**50.3***	5.0	39.2
3.8	**63.6***	6.3	25.1	5.1

*** : key** ; Red colour : most favourable distractor

MCQ 3.4

3.4 The figure shows a concrete building of dimensions 35 m × 40 m × 50 m. It is given that the Overall Thermal Transfer Value (OTTV) of a building should not exceed 24 W m^{-2}. Find the maximum number of windows, each of size 2 m × 3 m that can be installed on the walls of the building if the equivalent temperature difference between the interior and the exterior of the building is 10 °C.
Given: U-value of the concrete of the building = 2.0 W m^{-2} K^{-1}
U-value of the glass of the windows = 5.7 W m^{-2} K^{-1}



			A	B	C	D
A.	960		○	○	○	○
B.	598	favourable distractor 21.2%				
* C.	160	48.5%				
D.	120					

$A_1 = (35 \times 50 + 40 \times 50) \times 2 + 35 \times 40 - 2 \times 3 \times N$

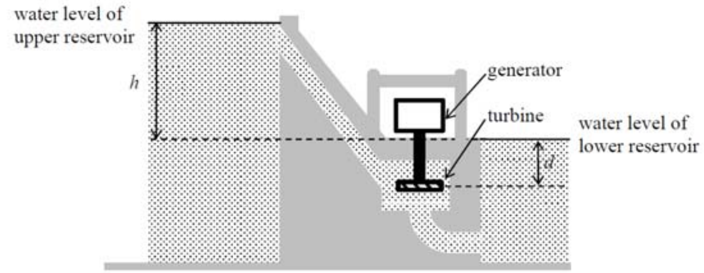
$A_2 = 2 \times 3 \times N$

$\text{OTTV} = 24 = \frac{(2.0 \times A_1 + 5.7 \times A_2) \times 10}{A_1 + A_2}$

$N = 160.3$

MCQ 3.7

3.7 The figure below shows a hydroelectric power plant.



Which factors below can affect the maximum power output of the plant ?

(1) The height difference between the water levels in the upper and lower reservoirs, h.
(2) The distance between the turbine and the water level of the lower reservoir, d.
(3) The rate of water flowing through the turbine.

				A	B	C	D
A.	(1) and (2) only			○	○	○	○
* B.	(1) and (3) only		50.3%				
C.	(2) and (3) only						
D.	(1), (2) and (3)	favourable distractor	39.2%				

Q.3 Structured question

Some information of electric vehicles A and B is tabulated below:

electric vehicle	battery capacity / kW h	maximum driving range / km	mass / kg
A	95	326	2500
B	66	414	1620

(a) Although the battery capacity of A is higher, its maximum driving range is shorter than that of B. State a possible reason and explain why. (1 mark)

(a) The size of A is larger, more energy is used to overcome air resistance / friction. OR The mass of A is larger, more energy is dissipated in accelerating and/or decelerating the vehicle. (Accept reasonable factors relating to conversion efficiency) 1A for state & explain	1A 1	Accept: The mass/weight of A is larger and therefore the friction is larger. The efficiency of the battery in A is lower and more energy is lost during energy conversion. Mass of A is larger and more energy / greater force is needed to accelerate / decelerate. NOT accept: Mass of A is larger and more energy is required for A to maintain the speed.

3ai. Because the mass of A is larger than the mass of B. Therefore, More energy is required to drive vehicle A under The same range compared to vehicle B. ∴ Maximum driving range of A is shorter than that of B.

0M

a) The mass of battery A is heavier. More energy is needed in carrying the battery along the driving range than battery B

0M

(a) A的質量較重，摩擦力較大，令能量損耗較多。

1M

In (a), very few candidates were able to point out that a more massive vehicle required a larger force/power for acceleration/deceleration.
A common misconception was that a larger force/power was for maintaining the speed of a more massive vehicle.

Q.3 Structured question

(b) (i) Suppose a charging voltage of 220 V is provided, estimate the minimum charging current required for charging the battery of vehicle *A* from completely discharged to fully charged in 12 hours. (2 marks)

(ii) Explain why in practice the charging current required is larger than that found in (b)(i). (1 mark)

(b) (i) 95×10^3 W h = 220 V $\times I\times$ 12 h I = 35.984848 A ≈ 36.0 A	1M 1A 2	1M for $P = VI$ AND $E = Pt$ Accept: 35.9 A – 36.1 A
(ii) The charging efficiency is not 100% / energy is lost in the charging process. Not accept: electricity lost, current lost, voltage lost	1A 1	Accept: Energy is lost as heat/thermal energy. Heat/thermal energy is produced during charging. NOT accept: Because of the resistance of the wires.

b i) $\frac{95\times1000\ (3600)}{220\ (I)} = 12\times3600$

$I = 36.0$ A to 3 sig fig

2M

ii) Some power will be loss during the transmission along the transmission line. A larger current is required to compensate the power loss.

1M

(b) (i) A所需要能量 E_A = 95 kWh = 342000 kJ

A完全充电需要的功率 $P_A = \frac{E}{t}$

$= \frac{342000\times1000}{12\times3600}$

= 7916.6667 W

1M

$P_A = VI_A$

7916.66667 = $\boxed{200}$ × I_A

Charging voltage??

I_A = 39.58333A

≈ 39.6A

(ii) 因為充电時，化学能轉換为电能時，能量或会流失，例如轉为車的熱能，即能量会轉为内能，因此需要更多电流。

1M

Part (b) was well answered. A few candidates mistook 220 V as the peak voltage while weaker ones treated kW h as a unit of power.

Q.3 Structured question

The table below shows more information about the electric vehicles:

electric vehicle	time required to accelerate from 0 to 100 km h^{-1} / s	peak power / kW
A	5.5	300
B	6.5	150

(c) Referring to all the information given, estimate

(i) the energy efficiency of vehicle *A*. You may assume that the vehicle is operating at its peak power. (2 marks)

Accept: calculating a, s then KE = m a s

(c) (i) Power out = $\frac{\frac{1}{2}mv^2}{t} = \frac{\frac{1}{2}\times2500\times\left(\frac{100}{3.6}\right)^2}{5.5} \approx \frac{9.64506\times10^5}{5.5}$ = 1.753648×10^5 W ≈ 175 kW Efficiency = $\frac{175}{300}\times100\%$ = 58.454920% ≈ 58.5%	1M 1A 2	1M for $\frac{\frac{1}{2}mv^2}{t}$ or correct substitution Accept: 58% – 59%

c) i) ~~$s = ut + \frac{1}{2}at^2$~~

~~100~~ $v = u + at$

100 km h^{-1} = 27.$\dot{7}$ m s^{-1}

27.$\dot{7}$ = 0 + a (5.5)

a = 5.0$\dot{5}$ m s^{-2}

F = ma F = 5.0$\dot{5}$ × 2500 ≈ 12626.3 N

0M

$\frac{12626.3\text{ N}\times\boxed{326\times1000}}{1\text{s}}$ = 411616 kW

Maximum driving range??

efficiency = $\frac{300\times1000}{411616}\times100\%$ = 72.9%

(c)(i) 能源效益 = $\frac{300\times5.5}{95\times326}\times100\%$ = 5.33%

0M

(c) (i) 效益 = $\frac{\text{輸出}}{\text{輸入}}\times100\%$

$= \frac{95000}{300\times326}\times100\%$ = 97.1%

0M

Q.3 Structured question

Some information of electric vehicles *A* and *B* is tabulated below:

electric vehicle	battery capacity / kW h	maximum driving range / km	mass / kg
A	95	326	2500
B	66	414	1620

(ii) the average output power from the battery of vehicle *B* if its average speed is 70 km h^{-1} in the maximum driving range test. (2 marks)

(ii) Total time taken for maximum driving range test $= \frac{414}{70} = 5.914286$ h ≈ 5.91 h	1M	1M for $\frac{414}{70}$ or 5.91 h
Power output $= \frac{66}{5.91}$ $= 11.159420$ kW ≈ 11.2 kW	1A	Accept: 11.0 kW – 11.5 kW
	2	

(ii) 平均功率 $= \frac{66}{70 \times 414}$

$= 2.28 \times 10^{-3}$ W

0M

(ii) $66 \times 1000 \div \left(\frac{414}{70}\right) = 11200$ W h^{-1}

Wrong unit

1M

Candidates did poorly in (c). As candidates had to tackle the questions from first principles using relevant data from the information given, not many were able to answer (c)(i)(ii) correctly.

Weaker ones mixed up input and output powers or made mistakes in unit conversions.

Q.3 Structured question

(d) Discuss in which of the driving modes below the regenerative braking system has the highest effectiveness: (2 marks)

Mode 1	driving at a few km per hour in often stop-and-go traffic conditions
Mode 2	driving in a city with smooth traffic regulated by traffic lights
Mode 3	driving on a highway

(d) Mode 2 (driving in a city with smooth traffic regulated by traffic lights) as (regenerative) braking can utilize the (relatively large) kinetic energy of the vehicle, say, when stopping at traffic lights.	1A+1A	1A for Mode 2 1A for explanation Mode 2: The regenerative braking system only works when the KE / speed is large.
OR Mode 1 (driving at a few km per hour in often stop-and-go traffic conditions) as (regenerative) braking needs to be applied often.	0A+1A	Mode 1: The brake is applied very frequently.
	2	

d) 模式3 因为車在高速公路上持續行駛加上高速，便能因而產生大量的動能以轉換成電能。

0M

d). 模式1需要經常停車，可以使再生制動模式發揮最大功效，另外兩種模式停車相對較少，功效發揮較小。

1M

(d) Mode 2 has the highest effectiveness. As part of K.E. will lost during braking but not being converted to electrical energy and stored in battery. More kinetic energy is lost in mode 1 as the braking is more often. For mode 3, there is almost no braking when driving on a highway, no kinetic energy will be converted and stored in battery.

1M

Candidates' performance in (d) was fair. It seems that they did not fully understand how a regenerative braking system works.

Quite a number of them wrongly chose Mode 3 (driving on a highway) to be the situation in which regenerative braking would be the most effective among the situations given.

Paper 2

Section B: Atomic World

HKDSE 2021

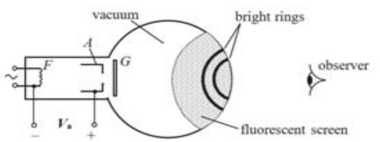
Multiple Choice

Qn.	1	2	3	4	5	6	7	8
A	17.9%	50.7%	22.3%	21.1%	14.7%	35.6%	22.4%	19.0%
B	16.1%	13.3%	14.9%	59.3%	14.9%	20.2%	16.1%	35.8%
C	56.0%	10.2%	23.5%	11.1%	54.2%	18.4%	9.9%	18.5%
D	9.7%	25.5%	38.5%	8.3%	16.0%	25.2%	51.3%	26.4%

KEY: Circled and underlined

Qn. 2.2

2.2 The figure shows an electron diffraction tube that can reveal the nature of electrons.



Electrons liberated from a heated filament F are accelerated by a high voltage V_a between F and anode A. The electrons then pass through a thin graphite film G and form bright and dark concentric rings on a fluorescent screen as shown. Which descriptions about this experiment are correct ?

(1) It demonstrates the wave nature of fast-moving electrons.
(2) Electrons are diffracted by the graphite film.
(3) If V_a increases slightly, the radii of the rings would increase.

A. (1) and (2) only — 50.7%
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3) — favourable distractor — 25.5%

A B C D

The most common mistake comes from (3). Some candidates did not realise an increase in $V_a \Rightarrow$ decrease in $\lambda \Rightarrow$ smaller degree of diffraction $\Rightarrow$ smaller circles.

Qn. 2.3

2.3 When monochromatic lights of wavelengths λ and 2λ are incident on a metal surface, the maximum kinetic energies of the photoelectrons emitted are in the ratio of 3:1. Find the longest wavelength of monochromatic light that can trigger photoemission for such metal.

A. $\frac{5\lambda}{2}$ — favourable distractor — 22.3%
B. 3λ
C. $\frac{7\lambda}{2}$ — favourable distractor — 23.5%
D. 4λ — 38.5%

A B C D

This question requires setting up a pair of simultaneous equations using $KE_{max} = hc/\lambda - \Phi$. Also the longest wavelength is corresponding to $KE_{max} = 0$. Most candidates cannot handle this and the outcome is rather random.

Qn. 2.6

2.6 When an electron of mass m and charge e is accelerated from rest by a voltage V, its de Broglie wavelength λ is given by $\lambda = \frac{h}{\sqrt{2meV}}$, where h is the Planck constant. If λ is expressed in nanometre (nm) and V in kilovolt (kV), then λ is approximately equal to

A. $\frac{0.04}{\sqrt{V}}$. 35.6%

B. $\frac{0.12}{\sqrt{V}}$. 20.2%

C. $\frac{0.4}{\sqrt{V}}$. 18.4%

D. $\frac{1.2}{\sqrt{V}}$. favourable distractor 25.2%

A B C D

The performance in this question was surprisingly poor. Candidates failed to understand that the formula is correct only if the unknowns are in SI units.
The easiest way is to replace λ *by* $\lambda \times 10^{-9}$; V *by* $V \times 10^3$ in the formula and then substitute the standard values of h, m and e to get the answer.

Qn. 2.8

2.8 A nano material

(1) has a higher volume to surface area ratio than the same substance in bulk form.
(2) has at least one dimension less than 1 nm.
(3) is chemically more reactive than the same substance in bulk form.

A. (1) only 19.0%
B. (3) only 35.8%
C. (1) and (2) only 18.5%
D. (2) and (3) only favourable distractor 26.4%

A B C D

Option (1) - Candidates may be careless as the opposite of this statement is correct.
Option (2) - Nano material has dimensions of order of nm, not necessarily smaller than 1 nm.

Q.2 Structural question

(a) Rutherford's planetary model of the atom failed to account for the stability of atoms. Why ? (1 mark)

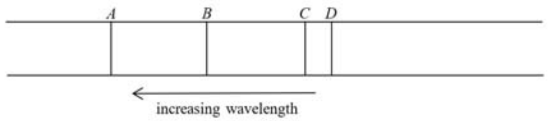
(a) In the model the orbital electron gradually loses its energy (via radiation) and spirals inwards until it finally crashes into the nucleus, i.e. the atom collapses.

Performance: Satisfactory
Common mistakes:
- The atom will collapse/is unstable according to Rutherford's model (no reason).
- The electron is attracted by the nucleus and hits the nucleus finally.

Q.2 Structural question

(b) The emission spectrum of hydrogen atoms only has four visible spectral lines (A to D) as shown in Figure 2.1.

Figure 2.1



All these lines belong to a series that corresponds to transitions to the first excited state ($n = 2$). In this series there are no spectral lines beyond A. The wavelengths λ (in nm) of all the spectral lines in the series are given empirically by the formula below.

$$\lambda = 364.6\left(\frac{n^2}{n^2 - 2^2}\right) \quad \text{where } n = 3, 4, 5, \cdots$$

(i) Which spectral line (A, B, C or D) comes from the electron transition between energy levels $n = 5$ and $n = 2$? (1 mark)

(b) (i) Line C (from $n = 5$ to $n = 2$)

Performance: Not satisfactory
- All four options (A, B, C and D) are commonly found. Answers are quite random.

Q.2 Structural question

(ii) Find the wavelength of the spectral line in (b)(i) and state the colour of this line. (2 marks)

(ii) $\lambda = 364.6\left(\dfrac{5^2}{5^2 - 2^2}\right)$	
$= 434.047619$ (nm) ≈ 434 (nm) or 435 (nm)	1A
Colour – violet / blue / indigo	1A

Performance: Good

Common mistakes:

- Wrong colour (e.g. red)
- Use wrong n (e.g. 4).

Remark:

- A few candidates did not use the provided formula and employed $13.6/n^2$ to find the answer.

Q.2 Structural Question

(iii) The remaining numerous invisible spectral lines in the series beyond line D are getting closer and closer until they finally converge to a limit of 364.6 nm. Suppose a photon of wavelength shorter than 364.6 nm collides with a hydrogen atom in the first excited state ($n = 2$). State what would happen to **the incident photon, the hydrogen atom** and **its orbital electron**. (3 marks)

(iii) The incident photon is absorbed.	1A
The hydrogen atom is ionized/becomes a hydrogen ion.	1A
The orbital electron becomes a free electron, (i.e. liberated with some kinetic energy)	1A

Performance: Fair

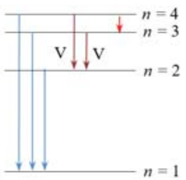
Common mistakes:

- Did not mention all three things happen to the atom, the electron and the photon (which is required by the question).
- *The photon loses some energy to the atom and left. The atom is excited. The electron jumps to a higher energy level.*
- *The atom can only absorb certain amounts of energy. As the energy of the photon is not those amounts, the photon leaves and nothing happens.*

Q.2 Structural question

(iv) Initially a group of hydrogen atoms are in the third excited state ($n = 4$). Illustrate with the aid of an energy level diagram **ALL** possible electron transitions that would produce **emission lines**. Mark a letter 'V' against the transition(s) that give(s) rise to visible spectral lines. (3 marks)

(iv)



(Total number of spectral lines = 6)

	2A	1A for at least two spectral groups (end at $n = 1$, $n = 2$ or $n = 3$) correct; 2A for all correct
	1A	Two visible lines correctly marked (must have indicated $3 \to 2$, $4 \to 2$)

Performance: Fair

Common mistakes:

- Only showed the transitions among 2, 3 and 4.
- Failed to mark the 'V' for transitions of visible spectra correctly.
- Did not show arrows or arrows are reversed.
- Did not draw the spectra in groups or spectral lines are duplicated. (Mark is not deducted here for this year.)

The End

HKDSE 2021
Physics Paper 2

Elective: Medical Physics

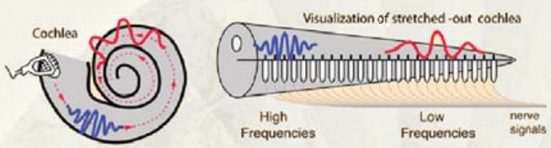
Multiple Choice Questions

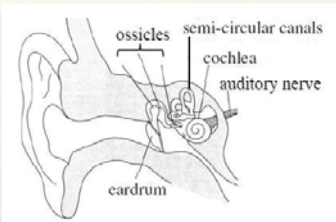
Qn	1	2	3	4	5	6	7	8
A	24%	15%	**27%**	11%	**51%**	15%	3%	17%
B	11%	**39%**	21%	18%	18%	23%	17%	**59%**
C	14%	20%	23%	**49%**	21%	**54%**	7%	19%
D	**51%**	26%	29%	22%	10%	8%	**73%**	5%

KEY: Circled and underlined

MCQ 4.1

Which part of the ear discerns frequency ?





A	24%	eardrum
B	11%	semi-circular canals
C	14%	ossicles
D*	**51%**	**cochlea**

favourable distractor

http://hyperphysics.phy-astr.gsu.edu/hbase/Sound/earsens.html

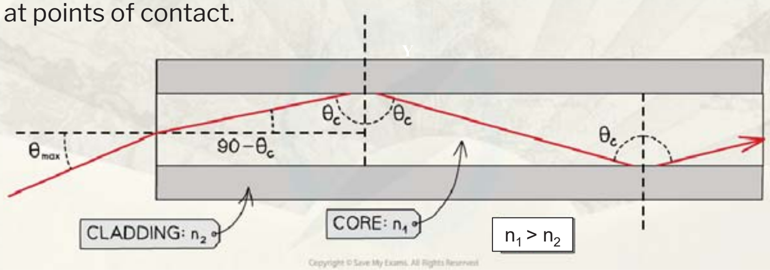
MCQ 4.2

Each optical fibre in an endoscope consists of a core enclosed by a cladding. The core and the cladding are made of two different transparent materials. Which descriptions about an optical fibre are **correct** ?

(1) The refractive index of the cladding is smaller than that of the core.

(2) The core-cladding boundary gives a smaller critical angle compared to a core-air boundary.

(3) Without cladding, some of the light rays would pass between optical fibres at points of contact.



https://www.savemyexams.co.uk/notes/a-level-physics-aqa/3-waves/3-5-refraction/3-5-3-fibre-optics/

MCQ 4.2

Each optical fibre in an endoscope consists of a core enclosed by a cladding. The core and the cladding are made of two different transparent materials. Which descriptions about an optical fibre are **correct** ?

(1) The refractive index of the cladding is smaller than that of the core.

(2) The core-cladding boundary gives a smaller critical angle compared to a core-air boundary.

(3) Without cladding, some of the light rays would pass between optical fibres at points of contact.

A	15%	(1) and (2) only	
B*	**39%**	**(1) and (3) only**	
C	20%	(2) and (3) only	
D	26%	(1), (2) and (3)	favourable distractor

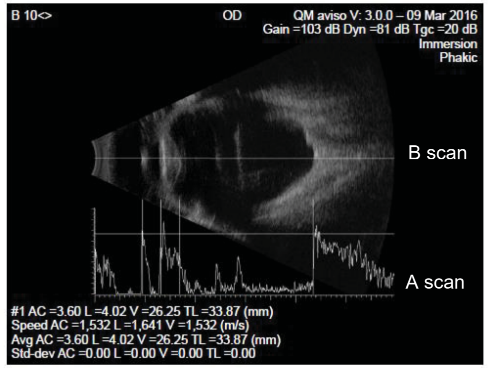
MCQ 4.3

Which descriptions about A-scan and B-scan of ultrasound imaging are correct ?

(1) B-scan is more useful for locating tumours.

(2) B-scan is employed for viewing the movement of an organ in real time.

(3) B-scan has a higher resolution.



Focused ultrasound in ophthalmology, Ronald H Silverman, Clinical Ophthalmology 2016:10 1865–1875

MCQ 4.3

Which descriptions about A-scan and B-scan of ultrasound imaging are correct ?

(1) B-scan is more useful for locating tumours.

(2) B-scan is employed for viewing the movement of an organ in real time.

(3) B-scan has a higher resolution.

A*	**27%**	**(1) and (2) only**	
B	21%	(1) and (3) only	
C	23%	(2) and (3) only	
D	29%	(1), (2) and (3)	favourable distractor

MCQ 4.4

When diagnosing brain injuries, doctors use computed tomography (CT) scans to locate positions of internal bleeding. With reference to this context, which reasons given below for NOT using the respective imaging methods are correct ?

(1) X-ray radiography: due to its insufficient resolution.

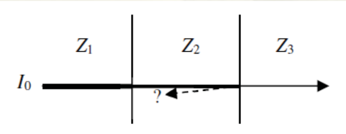
(2) Ultrasound scanning: as ultrasound cannot penetrate through the skull.

(3) Endoscopy: as there is no cavity in the brain for inserting an endoscope

A	11%	(1) and (2) only	
B	18%	(1) and (3) only	
C*	**49%**	**(2) and (3) only**	
D	22%	(1), (2) and (3)	favourable distractor

MCQ 4.5

A narrow beam of ultrasound of intensity I_o travels through three media of different acoustic impedances Z_1, Z_2 and Z_3 as shown.



	A*	51%
	B	18%
favourable distractor	C	21%
	D	10%

Assume that attenuation and absorption of ultrasound are negligible. What is the intensity of the ultrasound reflected from the interface between the media of acoustic impedances Z_2 and Z_3 ?

A. $\left[1-\frac{(Z_2-Z_1)^2}{(Z_2+Z_1)^2}\right]\frac{(Z_3-Z_2)^2}{(Z_3+Z_2)^2} I_0$

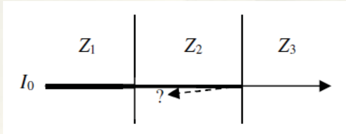
B. $\frac{(Z_2-Z_1)^2}{(Z_2+Z_1)^2}\frac{(Z_3-Z_2)^2}{(Z_3+Z_2)^2} I_0$

C. $\frac{(Z_2-Z_1)^2}{(Z_2+Z_1)^2}\left[1-\frac{(Z_3-Z_2)^2}{(Z_3+Z_2)^2}\right] I_0$

D. $\left[1-\frac{(Z_2-Z_1)^2}{(Z_2+Z_1)^2}\right]\left[1-\frac{(Z_3-Z_2)^2}{(Z_3+Z_2)^2}\right] I_0$

MCQ 4.5

A narrow beam of ultrasound of intensity I_o travels through three media of different acoustic impedances Z_1, Z_2 and Z_3 as shown.



	A*	51%
	B	18%
favourable distractor	C	21%
	D	10%

Assume that attenuation and absorption of ultrasound are negligible. What is the intensity of the ultrasound reflected from the interface between the media of acoustic impedances Z_2 and Z_3 ?

$$I_t^{12} = (1-\alpha_R^{12})I_o$$

$$I_R^{23} = \alpha_R^{23} I_t^{12} = \alpha_R^{23}\,(1-\alpha_R^{12})I_o$$

A. $\left[1-\frac{(Z_2-Z_1)^2}{(Z_2+Z_1)^2}\right]\frac{(Z_3-Z_2)^2}{(Z_3+Z_2)^2} I_0$

MCQ 4.6

The intensity of an X-ray beam is decreased by 25% after passing through a metal plate of thickness 0.01 m. Find the corresponding half-value thickness for this X-ray beam.

$$\left.\begin{array}{l} ln2 = \mu T_{1/2} \\ ln\left(\frac{3}{4}\right) = -0.01\,\mu \end{array}\right\} \quad T_{1/2} = \frac{ln2}{ln\left(\frac{3}{4}\right)}(-0.01)$$

A	15%	0.005 m	
B	23%	0.020 m	favourable distractor
C*	54%	0.024 m	
D	8%	0.042 m	

MCQ 4.7

Radionuclide imaging uses only γ radiations as

(1) γ can be deflected by a magnetic field to incident on the patient at any angle.

(2) γ has low ionizing power and causes less harm to cells.

(3) γ has high penetrating power and is detectable outside the body.

A	3%	(1) only	
B	17%	(3) only	favourable distractor
C	7%	(1) and (2) only	
D*	73%	**(2) and (3) only**	

MCQ 4.8

The radiation weighting factor of different radiations for calculating the effective dose are listed below:

α radiation	20
β radiation	1
γ radiation	1
X-rays	1

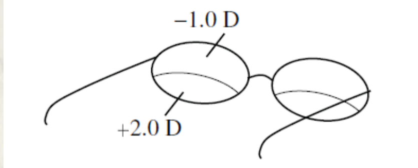
α is given a much larger radiation weighting factor because it

A	17%	has a low penetrating power.
B*	**59%**	**has a strong ionizing power.**
C	19%	has a relatively larger mass since it is a helium nucleus.
D	5%	is particle in nature. favourable distractor

Q.4(a)

Roger is suffering from eye defects and he has to wear the spectacles shown in Figure 4.1. The upper and lower halves of each lens are of powers –1.0 D and +2.0 D respectively.

Figure 4.1



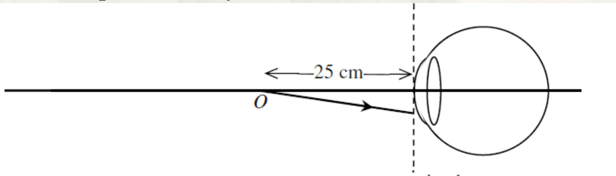
With the spectacles, Roger's near point can be corrected to 25 cm from his eyes while his far point is corrected to infinity. Assume that the lenses are very close to his eyes.

(i) State which half of the lens enables Roger to see distant objects clearly. Find the far point distance of his unaided eyes. (2 marks)

Q4(a)

(ii) Figure 4.2 shows a point object *O* placed at 25 cm in front of the corrective lens which is represented by a dotted line.

Figure 4.2



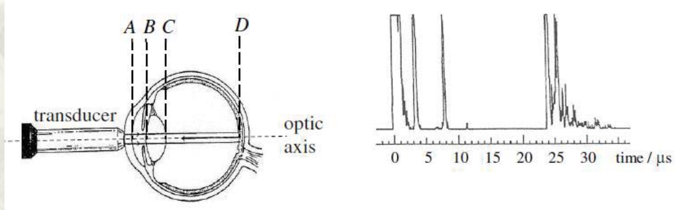
(1) **Copy Figure 4.2 to your answer book** and complete the path of the ray from *O* to show how it reaches the retina. Indicate the near point *N* of Roger's unaided eyes in your diagram. Assume that refraction in the eye is due to the eye lens only. (2 marks)

(2) Calculate the distance of *N* from his eyes. (2 marks)

Q.4(b)

(b) An ultrasound transducer is used to scan an eye as shown in Figure 4.3. The pulses reflected from interfaces *A*, *B*, *C* and *D* are recorded in the A-scan display below.

Figure 4.3



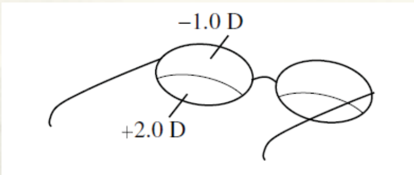
(i) Estimate the thickness of the eye lens along the optic axis.
Given: velocity of ultrasound in the eye lens = 1520 m s^{-1}. (2 marks)

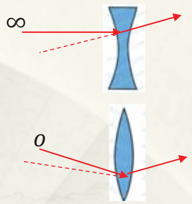
(ii) Explain which frequency of ultrasound, 3 MHz or 15 MHz, is preferred for scanning the eye. (1 mark)

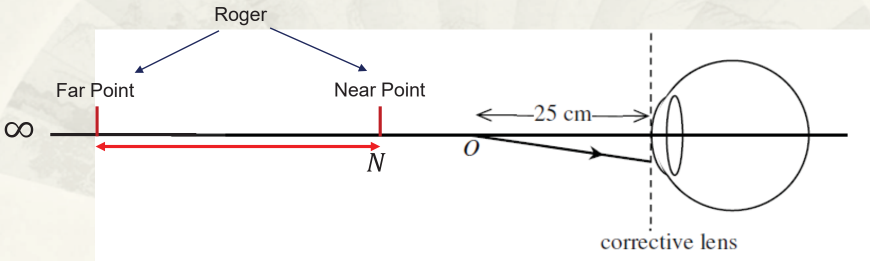
(iii) Apart from forming images in a diagnostic scan, name ONE medical application of ultrasound. (1 mark)

MS-Q4(a)(i)

4(a) (i)







MS-Q4(a)(i)

(a)(i) upper half

Power = –1.0 D

$f = \frac{1}{Power} = -1.0 \text{ m}$

Far point distance = 1.0 m = 100 cm (correct unit)

Alternative method 1 :

$$P = \frac{1}{f} = \frac{1}{\infty} + \frac{1}{v}$$

$$-1.0 = \frac{1}{-v} + \frac{1}{\infty}$$

where v refers to the far point (virtual image) of the unaided eyes

MS-Q4(a)(i)

Alternative method 2:

$$P_{eye} = \frac{1}{d} + \frac{1}{D_{eyeball}} \qquad (1)$$

$$P_{eye} - 1 = \frac{1}{\infty} + \frac{1}{D_{eyeball}} \qquad (2)$$

d = Far point of unaided eyes

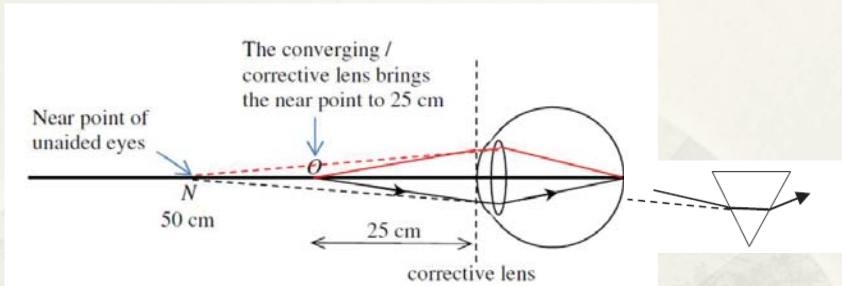
$D_{eyeball}$ = Diameter of eyeball

(2) – (1) gives

$$-1 = \frac{1}{\infty} - \frac{1}{d}$$

d = 1.0 m

MS-Q4(a)(ii)



Alternative Method 1:

$$P = \frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

Object distance = 0.25 cm

Virtual image distance = –d

$2.0 = \frac{1}{0.25} + \frac{1}{-d}$ => d = 0.5 m

Near point distance d of the unaided eyes = 0.5 m = 50 cm

MS-Q4(a)(ii)

Alternative method 2:

$$P_{eye} = \frac{1}{d} + \frac{1}{D_{eyeball}} \quad (1)$$

$$P_{eye} + 2 = \frac{1}{0.25} + \frac{1}{D_{eyeball}} \quad (2)$$

d = Near point of unaided eyes

$D_{eyeball}$ = Diameter of eyeball

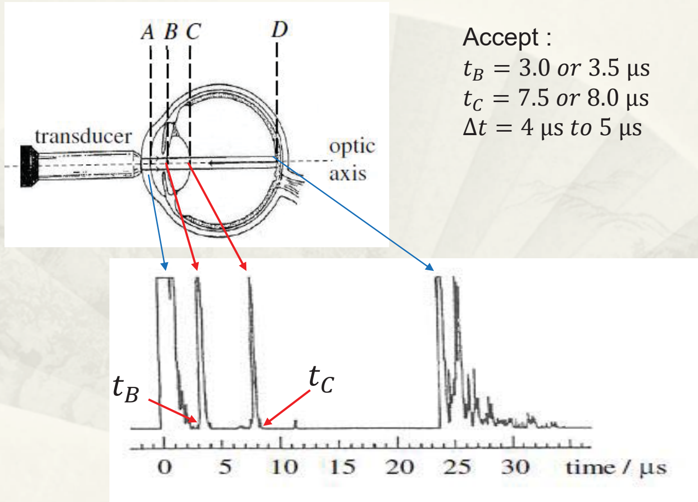
(2) – (1) gives

$$2 = \frac{1}{0.25} + \frac{1}{-d}$$

$d = 0.5$ m

MS-Q4(b)(i)

(i)



Accept :
$t_B = 3.0 \text{ or } 3.5$ μs
$t_C = 7.5 \text{ or } 8.0$ μs
$\Delta t = 4$ μs to 5 μs

MS-Q4(b)(i)

Accept :
$t_B = 3.0 \text{ or } 3.5$ μs
$t_C = 7.5 \text{ or } 8.0$ μs
$\Delta t = 4$ μs to 5μs

Speed of ultrasound = v

Thickness of eye lens $(d) = \frac{v\Delta t}{2}$

$d = \frac{1}{2}(1520 \text{ m s}^{-1})(5\text{x}10^{-6} \text{ m}) = 3.8$ mm / 0.38 cm / 3.8×10^{-3} m

OR :

$d = \frac{1}{2}(1520 \text{ m s}^{-1})(4\text{x}10^{-6} \text{ m}) = 3.04$ mm / 0.304 cm / 3.04×10^{-3} m

MS-Q4(b)(ii & iii)

(ii) 15 MHz should be chosen for **higher (axial) resolution**, OR 15 MHz gives a shorter wavelength (~ 0.023 mm) than 3 MHz (~ 0.11 mm) for **higher (axial) resolution**.

The ultrasound pulses detect structures near surface, absorption and attenuation are small.

(iii) Any ONE of the applications:
-Break up stones in kidney, gall bladder etc.
-Break down crystalline eye lens in cataract surgery
-To remove calculus from surface of teeth in dentistry.
-High intensity ultrasound to destroy tumours (surgery).
-Speed up bone healing after a fracture.
-Therapeutic uses:
reduce pain, increase circulation and increase mobility of soft tissues, reduce inflammation and healing of injuries and wounds

ai) The upper half. ✓ 1A

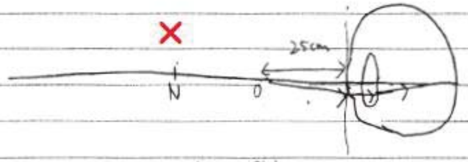
$-1 = \frac{1}{v}$

$v = -1\,m$

Far pt is 1m ✓ 1A

ii)

(1) ✗



✓ 1A

(2) ~~$\frac{1}{0.25} + \frac{1}{v}$~~

$2 = \frac{1}{0.25} + \frac{1}{v}$ ✓

$v = -0.5$

virtual image -ve

Near pt = 0.5m ✓

1A

4bi) $2D = 1520(5\times10^{-6})$ ✓ 1M

$D = 3.8\times10^{-3}\,m$ ✓ 1A

5 µs is accepted

ii) ~~15~~ Frequency with 15MHz is preferred as high frequency has high resolution and eyes is on the surface of body, so high frequency is preferred, ~~but~~ not also it doesn't need high penetrating power. ✓ 1A

iii) Detect crack in railway. ✗

---

a(i) The upper ✓ half (−1.00) part of the lens enables Roger to see distant objects clearly. 1A

$\frac{1}{\infty} - \frac{1}{v} = \frac{1}{f}$

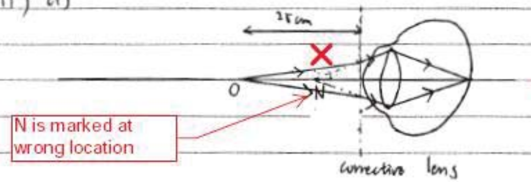
$-\frac{1}{v} = P$

$-\frac{1}{v} = -1$

$v = 1\,m$

∴ The far point distance is 1m. ✓ 1A

(ii) (1)



✓ 1A

(2) $\frac{1}{0.25} - \frac{1}{v} = \frac{1}{f}$ ✓ 1M

$= P$

$\frac{1}{0.25} - \frac{1}{v} = -1$ ← Power of lens is 2D

$V = 0.2\,m$

∴ The distance of N is 0.2m ✗

---

b(i) Thickness $= 1520 \times (8-3)\times10^{-6} \times \frac{1}{2}$ ✓ 1A

$= 3.8\times10^{-3}\,m$ ✓ 1A

(ii) 15MHz, as high frequency ultrasound can have a higher resolution. Besides, the eye is near the surface of body, so the penetrating power no need to be too high. ✓ 1A

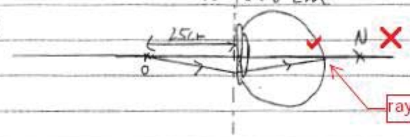
(iii) To break the stone inside the kedney.. ✓ 1A ai) 下半片。 ✗

$\lambda = (1.22)\frac{25}{100} \div 1 = 0.305$

遠點距離 $= (1.22)(0.305) \div 2 = 0.18605$ m ✗

≈ 18.6 cm

aii) (1)



✗ 1A

ray path reaches retina

(2) N與眼睛距離 $= (1.22)(0.305) \div 1$ ✗

$= 0.3721$ m

≈ 37.2 cm

bi) 所求厚度 $= 1520 \times ((7-4) \times 10^{-6})$ ✗ ✗

$= 4.56 \times 10^{-3}$ m ✗

bii) 3 MHz ✗，眼睛較小使用 3MHz 成像較清晰。

biii) 掃描在母體內嬰兒生長狀況。 ✗

Thickness x 2

outside range and not divided by 2

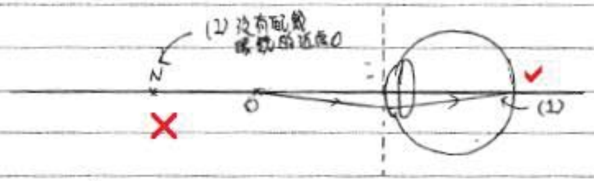
Q4:

(a)(i) 下半的鏡片，即 +2.0D 的鏡片能让他看清楚近的物体。 ✗

$P = \frac{1}{f}$ $\qquad \frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ ✗

$+2.0 = \frac{1}{f}$

(a)(ii)(1)



✗ ✓ 1A

(2) $P = \frac{1}{f}$

$-1.0 = \frac{1}{f}$

$f = 1$ cm ✗

(b)(i) $V_{oc} = \frac{d}{t}$ ✓ 1M

$1520 = \frac{d}{24-3}$

$d = 0.01381 5789$

晶體的厚度 $= \frac{d}{2} = \frac{0.0138157894}{2} = 6.9078947 37 \times 10^{-3}$ m ✗

≈ 0.691 cm

✗

2(thickness)=vt

wrong measurement

(ii) 以 3MHz 的超声波掃描眼睛較为合適，因为根据 $v = f\lambda$，$\lambda \propto \frac{1}{f}$，频率越高的超声波，其波長越短，它难以分辨眼睛的结构相近。

(iii) 粉碎石震碎，小型膀石手術。 ✓ 1A

4(a)(i) 上半部分 ✓ 1A

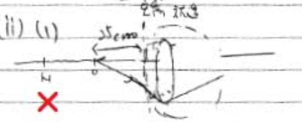
$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

$\frac{1}{u} + \frac{1}{\infty} = \frac{1}{f} - 1$

$\frac{1}{u} + \frac{1}{\infty} = \frac{1}{u} + \frac{1}{v} - 1$

$v = 1$m ✓ 1A

(ii)(1)



✗ ✗

(2) $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ ✓ 1M

$\frac{1}{u} + \frac{1}{0.25} = \frac{1}{f} + 2.0$

$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

$\frac{1}{u} + \frac{1}{0.25} = \frac{1}{u} + \frac{1}{v} + 2.0$

$u = 28.6$cm ✗

(b)(i) 厚度 $= \frac{5}{2} \times 10^{-6} \times 1520$ ✓ 1M

$= 3.8 \times 10^{-3}$ m ✓ 1A

(ii) 3MHz，因為眼睛的反射声波強烈. 从而可獲得更清楚的像 ✗

(iii) 清除耳道的異物 ✗

The End