2016 HKDSE Physics & Combined Science (Physics)

Report on Assessment

Y.T.SZETO
Manager (Physics), HKEAA

3 & 13 Oct 2016

Overview

Paper	Physics	CS(Phy)
1A (MC)	Mean: 17.2 out of 32* (i.e.54%) (2015: 17.3 out of 33)	Mean: 8.5 out of 21* (i.e.41%) (2015: 8.5 out of 22)
1B	~<50% (2015: ~<50%)	~<30% (2015: ~<30%)
2	~<50% (2015: ~<50%)	N.A.
SBA	~>70% (~2015)	<70% (~2015)
Candidature	ALL: 12 170 SCH: 11 283	ALL: 630 SCH: 574

* one item deleted

Marking & Grading

On-Screen Marking (OSM) panels	
Physics	**CS(Phy)**
1B-1: Q.1, 3, 4 (28M) 1B-2: Q.5, 7, 8 (31M) 1B-3: Q.2, 6, 9 (25M)	1B-1: Q.1, 2, 3 (28M) 1B-2: Q.4, 5, 6 (28M) ---
2A: Astronomy (20%) 2B: Atomic World (68%) 2C: Energy (85%) 2D: Medical Physics (27%)	---

SBA marks stat. moderated with both Mean and SD adjusted (outlining cases reviewed by Supervisors)

Marking & Grading

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

Note: GAI is calculated from Physics candidates' actual percentage awards obtained in 4 core subjects CEML.

Results

Physics

Cut score difference = 44 marks

Level	5**	5+	4+	3+	2+	1+
Percentage	2.7%	26.5%	50.9%	74.0%	90.9%	97.9%
No. of MC	**29/30**	**22**	**17**	**13**	**10/9**	**7/6**

CS(Phy)

Cut score difference = 35 marks

Level	5**	5+	4+	3+	2+	1+
Percentage	0.9%	9.6%	25.5%	52.5%	73.3%	92.0%
No. of MC	**17/18**	**14**	**11**	**9/8**	**7**	**5/4**

Paper 1A

Physics (33 MC with 1 deletion)

>70%	50%-70%	<50%
8	9	15

Easy ⟷ Difficult

CS (Phy) (22 MC with 1 deletion)

>70%	50%-70%	<50%
1	5	15

Easy ⟷ Difficult

PHYSICS MC

Topic (No. of Qu.)	Average % correct	No. of Qu. < 50% correct
Heat & Gases (3)	48%	2
Force & Motion (11)	51%	5
Wave Motion (9)	59%	4
Electricity & Magnetism (7)	50%	4
Radioactivity (2)	72%	0

CS(PHY) MC

Topic (No. of Qu.)	Average % correct	No. of Qu. < 50% correct
Heat & Gases (2)	24%	2
Force & Motion (7)	35%	5
Wave Motion (7)	50%	4
Electricity & Magnetism (5)	37%	4

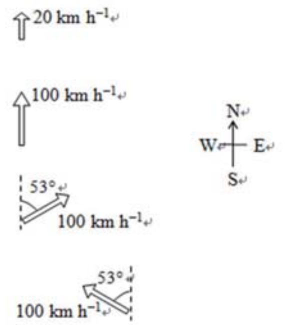
2. 0.3 kg of water at temperature 50 °C is mixed with 0.2 kg of ice at temperature 0 °C in an insulated container of negligible heat capacity. What is the final temperature of the mixture ?

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

specific latent heat of fusion of ice = 3.34×10^5 J kg^{-1}

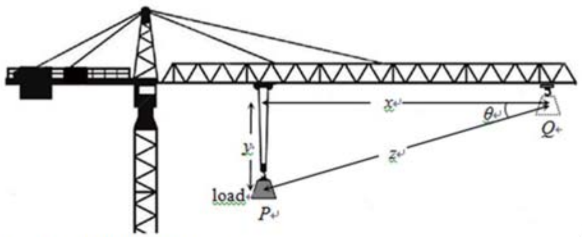
			PHY	CS(PHY)
	A.	−1.8 °C	(26%)	(29%)
*	B.	0 °C	(39%)	(17%)
	C.	1.8 °C	(22%)	(31%)
	D.	3.0 °C	(13%)	(23%)

5. A car travelling at 80 km h^{-1} due east changes direction and travels at 60 km h^{-1} due north. Which diagram represents the change in velocity of the car ?



		PHY	CS(PHY)
	A.	(4%)	(10%)
	B.	(2%)	(5%)
	C.	(76%)	(72%)
*	D.	(18%)	(13%)

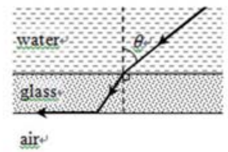
9. A crane moves a load of weight W steadily from point P to point Q as shown.



The work done on the load by the crane is

			PHY	CS(PHY)
*	A.	Wy.	(25%)	(13%)
	B.	$W(x + y)$.	(13%)	(14%)
	C.	Wz.	(17%)	(12%)
	D.	$Wz \cos \theta$.	(45%)	(61%)

17.

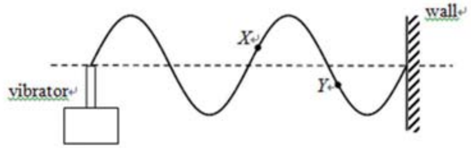


A parallel-sided glass sheet separates water from air. A ray of light in water is incident at an angle θ on the glass sheet and finally emerges into air along the glass-air interface as shown. Find θ.

Given: refractive index of water is 1.33.

			PHY	CS(PHY)
	A.	41.2°	(7%)	(9%)
*	B.	48.8°	(48%)	(33%)
	C.	53.1°	(8%)	(9%)
	D.	It depends on the refractive index of glass.	(37%)	(49%)

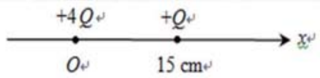
18. A string is tied to a vibrator while the other end is fixed to a wall. A stationary wave is formed as shown.



Which statement is correct when the frequency of the vibrator doubles ?

	A.	The wavelength will double.	(4%)
	B.	The wave speed will double.	(33%)
	C.	The amplitude will be halved.	(14%)
*	D.	Particles X and Y will become vibrating in phase.	(49%)

24.



Point charges $+4Q$ and $+Q$ are fixed on the x-axis with $+4Q$ at the origin O and $+Q$ at $x = 15$ cm as shown. The respective electric fields due to the two charges are equal at

	A.	$x = 10$ cm.	(34%)
	B.	$x = 12$ cm.	(20%)
	C.	$x = 20$ cm.	(16%)
*	D.	$x = 30$ cm.	(30%)

26. Two filament light bulbs X and Y are connected in parallel to a dry cell. X is brighter than Y. Which statements are correct ?

(1) In 1 s, the number of charges flowing through X is greater than that flowing through Y.
(2) In 1 s, the electrical energy dissipated by X is greater than that dissipated by Y.
(3) For every unit charge passing, the electrical energy dissipated by X is equal to that dissipated by Y.

			PHY	CS(PHY)
	A.	(1) and (2) only	(37%)	(49%)
	B.	(1) and (3) only	(17%)	(21%)
	C.	(2) and (3) only	(13%)	(14%)
*	D.	(1), (2) and (3)	(33%)	(16%)

Observations

- Although most candidates were competent in handling calculations, their misconceptions were revealed in several questions which involve fundamentals of Physics.
- Not quite understand some experiments and the precautions / procedures involved.
- Quite weak or careless in handling units/converting units or scientific notations.
- Weaker candidates (Level 1 & 2) tend to give up answering some questions.
- Performance is unsatisfactory in Paper 2.

Points to note

- As in previous years, ~70% of Paper 1 (Physics) with questions from core part.
- Accept using g = 9.81 or 10 m s^{-2}.
- Method marks 'M' awarded to correct formula / substitution / deduction
- In general, numerical ans. with 3 sig. fig. Answer marks 'A' awarded to correct numerical answer in correct unit within <u>tolerance range</u>.

Points to note

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

  Before equating: Mean 32 to 36 / SD 18 to 21
  After equating: Mean 36 to 41 / SD 16 to 18

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

Points to note

- Student samples of performance (Levels 1 to 5) available in October (HKEAA website).
- SBA Conference on 29 Oct 2016
- SBA Online Submission in Jan/Feb 2017
- All SBA tasks adopt <u>0 – 20 mark range</u>.

THANK YOU

HKDSE PHYSICS
Paper 1B Q 1, 3, 4

Question 1a

1. The following experimental items are provided for estimating the specific heat capacity of bronze c_b:

    a bronze sphere of mass 0.80 kg hung with a thread at room temperature T_0
    a polystyrene cup containing 0.50 kg of water at room temperature T_0
    a water bath maintained at 80 °C
    a thermometer
    a stirrer
    a towel

    (a) Describe the procedures of the experiment and state **TWO** experimental precautions to be taken. Write down an equation for finding c_b.
    Given: specific heat capacity of water = 4200 J kg^{-1} °C^{-1} (6 marks)

Question 1a

1.	(a)	- Put the sphere into the water bath for a few minutes	1A
		- Put / transfer the sphere into the polystyrene cup (of water)	1A
		- Measure the final / maximum temperature T_f of the water with a thermometer	1A
		Precautions:	
		- Dry the sphere with the towel quickly before putting it into the cup (related to mass)	Any TWO: 1A
		- Make sure it is fully immersed in water (related to energy)	1A
		- Stir the water thoroughly (related to temp)	
		$0.80 \times c_b \times (80 - T_f) = 0.50 \times 4200 \times (T_f - T_0)$	1A

Marking Remarks

- 1st mark – heat the sphere to 80 °C by water bath.
- 2nd mark – mix a hot object with cold object.
- 3rd mark – measure final temp. by thermometer.
- Precautions:
  - 1 A only for precautions in same group (mass, energy, temp)
  - NOT accept: wrap the polystyrene cup by towel

Candidates' performance

- many candidates failed to figure out how to raise the temperature of the sphere to 80 °C by using the water bath given.
- Some candidates heat the cup of water instead of the sphere by the water bath.
- Some mistook the towel for insulation of the polystyrene cup rather than drying the sphere.

Question 1b

(b) The value of c_b found in the experiment in (a) is lower than the actual value. Explain. (2 marks)

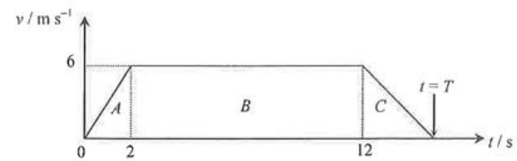
(b)	Thermal energy / heat is lost during the transfer / drying of the sphere.	1A
	Or Thermal energy / heat absorbed by thermometer, stirrer or cup.	1A 1A
	Or The temperature of the sphere is higher than T_f when this final temperature is measured (i.e. T_f not reaching its maximum)	
	Thus temperature rise of water in the cup is lower than it should be.	1A

Candidates' performance

- performance was satisfactory.
- some candidates failed to point out that the temperature rise of water is lower than it should be.

Question 3

3. A person of mass m stands on a balance inside a lift. The lift goes down from the top of a building at time $t = 0$ and it reaches the ground at $t = T$. The velocity-time (v-t) graph of the lift is shown in Figure 3.1. ($g = 9.81$ m s^{-2})



(a) Calculate the acceleration of the lift from $t = 0$ to $t = 2$ s. (2 marks)

The reading of the balance changes during the person's ride on the lift and the readings registered are 685 N, 569 N and 395 N.

(b) Match these readings with the three stages, A, B and C, of the ride (shown in Figure 3.1). Hence deduce the mass of the person. (3 marks)

(c) (i) Show that $T = 15$ s. (2 marks)

(ii) Hence estimate the height of the building. (2 marks)

Question 3

3.	(a)	$a = \dfrac{6-0}{2-0}$	1M
		$= 3\ \text{m s}^{-2}$ (downwards)	1A

(b)	A: 395 N $\quad B$: 569 N $\quad C$: 685 N	1A
	In stage B, balance reading = weight (Newton's 1st law),	
	$mg = m \times 9.81\ \text{m s}^{-2} = 569\ \text{N}$	1M
	$m = 58.0\ \text{kg}$	1A

Or In stage A, according to Newton's 2nd law,	
$(569 - 395)\ \text{N} = ma = m(3\ \text{m s}^{-2})$	1M
$m = 58.0\ \text{kg}$	1A

Question 3

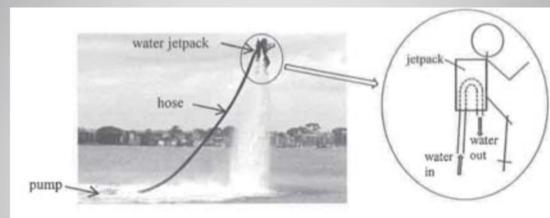
(c)	(i)	For stage C, by Newton's 2nd law,	
		$F = ma$	
		$(569 - 685)\ \text{N} = (58.0\ \text{kg})\, a$	1M
		$a = -2\ \text{m s}^{-2}$	
		Thus, $a = \dfrac{0-6}{T-12} = -2\ \text{m s}^{-2}$	1M
		$T = 15\ \text{s}$	

(ii)	Height $\approx$ displacement of lift = area under graph	1M
	$= \dfrac{(12-2)+15}{2} \times 6$	
	$= 75\ \text{m}$	1A

Candidates' performance

- performance was satisfactory.
- In (c)(i), some candidates failed to verify the result as they made mistakes in the sign of acceleration in the calculation.

Question 4ab



4. A person wears a water jetpack which enables him to stay 'afloat' in equilibrium in the air as shown in Figure 4.1. A pump on the sea surface continuously pumps water to the jetpack via a hose and the water is then ejected downwards.

(a) Referring to Figure 4.1, water enters the U-shape hose inside the jetpack with a certain speed and is then ejected out vertically downwards. Use Newton's law(s) of motion to explain why a lifting force acting on the person is produced. (3 marks)

(b) Draw and label all the forces acting on the person wearing the jetpack as a whole in the free-body diagram below. Neglect the pulling force due to the hose connected to the jetpack. (1 mark)

Question 4a

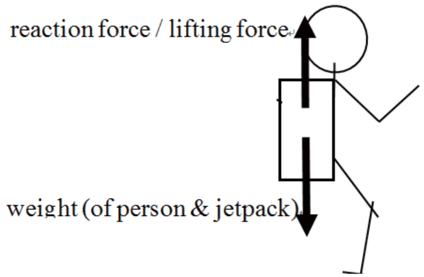
4.	(a)	According to Newton's second law of motion / $F = (mv-mu)/t$ a (net) force acts on the water so as to change its momentum (or magnitude of the force equals the rate of change of momentum of water).	1A
		According to Newton's third law of motion,	1A
		a force acting downwards on the ejecting water (by the jetpack), the water exerts a reaction (equal but upward / opposite) on the jetpack / person as well.	1A

Candidates' performance

- performance was poor.
- few candidates knew that the momentum change of water requires a net force from the jetpack
- many candidates had a misconception that this force comes from the interaction between the water ejected from the jetpack and the water surface.

Question 4b

(b)



1A

Accept symbol *W*, *mg*, *R*, *N*

Question 4cd

(c) Suppose that water enters the jetpack with a speed of 10 m s^{-1} vertically upwards and is then ejected out at the same speed vertically downwards. ($g = 9.81$ m s^{-2})

(i) **Just by considering the change of momentum of the water**, estimate how much water, in kg, has to be ejected per second to provide a lifting force of 1000 N needed. (2 marks)

(ii) Water is pumped to the water jetpack at a height of 7.5 m above sea surface and then ejected from it. By considering the gain in mechanical energy of the water, estimate the minimum output power of the pump. (3 marks)

(d) The person changes to staying 'afloat' in equilibrium at a higher position. If the speed by which water enters and is ejected from the jetpack remains the same, would the amount of water ejected per second be greater than, equal to or smaller than the result found in (c)(i) ? Explain. (Neglect the weight of the hose.) (2 marks)

Question 4cd

(c)	(i)	$F = \frac{\Delta p}{\Delta t} = \frac{\Delta m}{\Delta t} \times (\vec{v} - \vec{u})$	1M
		$\frac{\Delta m}{\Delta t} \times (10 - (-10))\ \text{m s}^{-1} = 1000\ \text{N}$	
		$\frac{\Delta m}{\Delta t} = 50\ (\text{kg s}^{-1})$	1A
	(ii)	$(\frac{\Delta m}{\Delta t})gh + \frac{1}{2}(\frac{\Delta m}{\Delta t}) \times v^2$ Accept using m for $\Delta m/\Delta t$	1M+1M
		$= (50\ \text{kg s}^{-1})(9.81\ \text{m s}^{-2})(7.5\ \text{m}) + \frac{1}{2}(50\ \text{kg s}^{-1}) \times (10\ \text{m s}^{-1})^2$	
		$= 6178.75\ \text{W}$	1A
(d)	The same		1A
	as the same lifting force / (water) jet speed is needed.		1A

Candidates' performance

- Some candidates had difficulty in applying *F*=Δ*p*/Δ*t* to find *F* as the directions of water flow needed to be considered.
- In (c)(ii), a few candidates did not know what mechanical energy consists of.
- Candidates' performance in (d) was unsatisfactory. Some suggested that a greater power is required for the person to stay at a higher position.

HKDSE

PHYSICS 1B-2

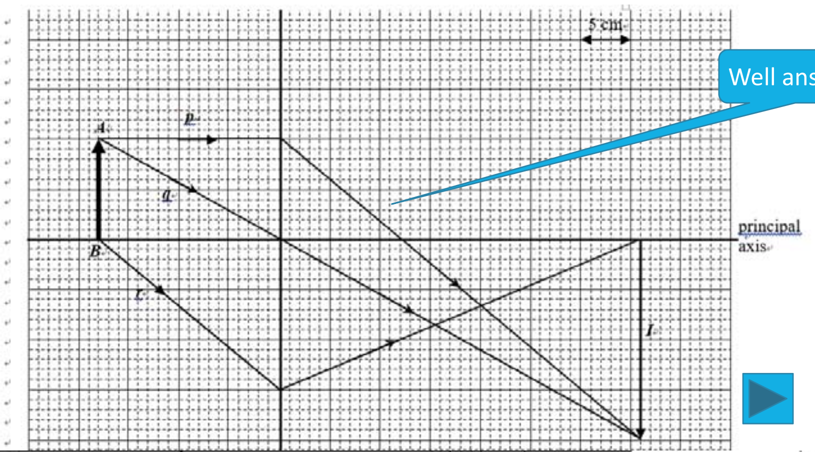
QUESTIONS 5, 7 & 8

			Solution	Marks	Remarks
5.	(a)	(i)	Convex (lens) Only convex lens forms real image (which can be captured by a screen) Or concave lens always forms virtual image (which cannot be captured by a screen) Or The image is formed on the other side of the lens	1A 1A 1A 1A	Correct spelling of "convex"
				2	
		(ii)	opaque screen	1A	
				1	
	(b)	(i)	Image distance $v = 54 - 18 = 36$ cm ($D = 54$ cm) Magnification $= \frac{v}{u} = \frac{36}{18} = 2 \pm 0.01$	1A 1A	
				2	

Well answered.

Common errors:
Ignored the position of the observer given in the diagram and hence failed to score.

Common errors:
Failed to state the image distance correctly.



Well answered.

			Marks	Remarks
	(ii)	Image I of AB Rays p and q Ray r	1A✓ 1M✓ 1M✓	1A for correct position of I
		Deduct 1 mark for : Incorrect orientation of I / Incorrect direction of light rays / Drawing light rays / image with dashed lines		

		Solution	Marks	Remarks
	(iii)	Focal length = 12 ± 0.5 cm	1M/1A	
			1	
	(iv)	Move the lens (18 cm) farther away from the object. Or move the lens (18 cm) closer to / towards the screen. Height ratio = 1 : 4.	1A 1A 1A	Accept $u = 36$ cm OR $v = 18$ cm
			2	

Well answered.

Poorly answered.

Common errors:
Only stated that the lens should be moved towards the screen but not by how much.
Misread the ratio (height of this new image/height of the original image) as height of the image/height of object and gave an incorrect answer (1/2)

Solution	Marks	Remarks
7. (a) (i) $R = 10\ \text{k}\Omega$ (circuit I)		1M for appropriate method in calculating voltage
$V = \frac{(10k \parallel 10k)}{10k + (10k \parallel 10k)} \times 6$	1M	
$= 2\ \text{V}$	1A	
$R = 100\ \Omega$ (circuit II)		
$V = \frac{(100 \parallel 10k)}{100 + (100 \parallel 10k)} \times 6$		
$= 2.985\ \text{V}$		
	3	
(ii) Resistance of circuit / that part of circuit would be lowered / altered significantly when introducing the voltmeter (i.e. loading effect).	1A	
Or The resistance of the voltmeter is comparable to the resistance of resistor R.	1A	
Resistance of voltmeter should be much higher than the resistance of the part of the circuit under study.	1A	

In circuit II, some candidates gave a slightly wrong numerical answer (2.97 V) due to rounding at an earlier stage of the calculation.

Well answered.

Solution	Marks	Remarks
(b) (i) V_m does **NOT** give the true voltage for the resistor.	1A	
$R_m = R_A + R$	1A	
	2	
(ii) For circuit III.		
$R_m = R + R_A = 10 + 1 = 11\ \Omega$		
percentage error $= \frac{1\,\Omega}{10\,\Omega} \times 100\ \%$	1M	1M for correct method in calculating percentage error
$= 10\%$	1A	
	2	

Common errors :
Tried to calculate the equivalent resistance of the whole circuit (R, R_A and R_V) instead, this error was usually carried forward to the answer in 7(b)(ii).

Many candidates failed to score marks because they had no idea in calculating percentage error.

Solution	Marks	Remarks
8. (a) (i) - the air loses its insulating properties	1A	
Or electrons or ions can pass through the air (between clouds and Earth or between clouds and clouds)	1A	
	1	
(ii) $E = \frac{V}{d}$	1M	1M for quoting correct eqn.
$V = E\,d = (3 \times 10^5) \times 2000$		
$= 6.0 \times 10^8\ \text{V}$	1A	
	2	

Common errors:
wrongly thought that "breakdown" meant "lightning".

Well answered.

Common errors:
Careless mistake in changing the subject of equation

Solution	Marks	Remarks
(b) (i) magnetic field into paper (due to upward lightning current)	1A	
$B = \frac{\mu_0 I}{2\pi r}$	1M	1M for quoting correct eqn.
$= \frac{4\pi \times 10^{-7} \times 30000}{2\pi \times 1500}$		
$= 4.0 \times 10^{-6}\ \text{T}$	1A	
	3	
(ii) When the lightning current is increasing, the induced current flows in the anticlockwise direction so as	1A✓	1A for correct directions of induced current
to oppose the increasing magnetic field (into paper).	1A✓	
After reaching maximum, the lightning current is decreasing, the induced current flows in the clockwise / opposite direction.	1A✓	
	3	

Well answered.

Common errors:
Gave the numerical answer with wrong unit (e.g. Bq, V m^{-1}, Wb, etc.)

Common errors:
Some answers were too vague to score marks

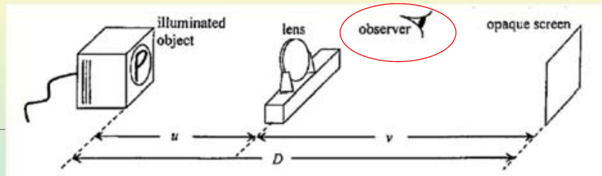
Solution	Marks	Remarks
(iii) Electric field (in the atmosphere).	1A	
E-field increases / builds up (to threshold) before lightning happens	1A	
Or lightning current and magnetic field only exist during lightning	1A	
	2	

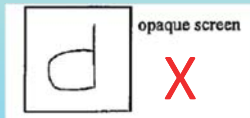
Common errors:
Failed to realize that electric field builds up before lightning

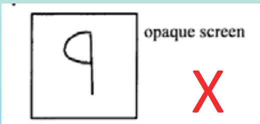
---

Thanks

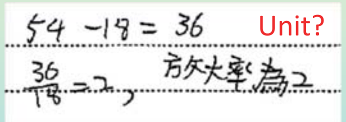
Q5(a)(ii)

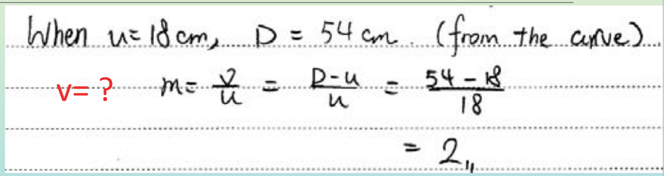


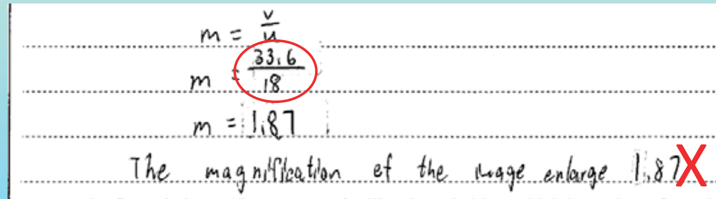




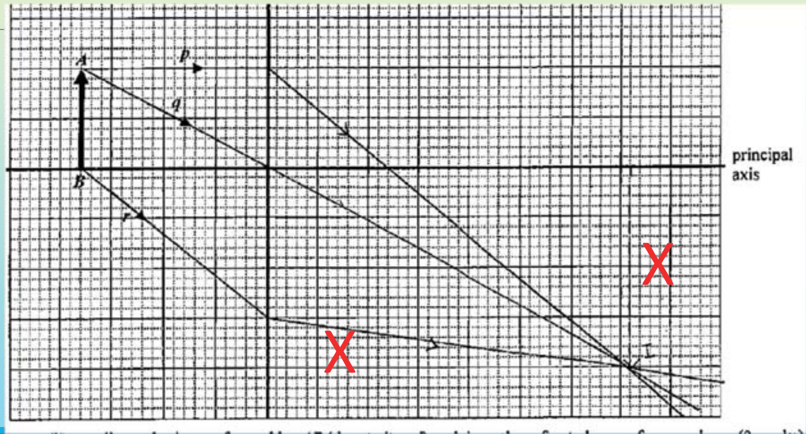
Q5(b)(i)







Q5(b)(ii)



Q5(b)(iv)

From the graph, when D is still 56 cm,
u can be 18 cm or 36 cm
when u is 36 cm,

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

$\frac{1}{36} + \frac{1}{m(36)} = \frac{1}{12}$

$m = 1$

(2 marks)

Kitty should move the lens away from the object.
As the object lies on a position two times of its focal length, the image formed would have the same size as the object.
So the ratio would be $\frac{1}{1} = 1:1$ for $\frac{\text{height of the new image}}{\text{height of the original image}}$

成，指出 原本像的高度 之比。

应移向距离物体 36 cm處，則比为 $\frac{18}{36} = 0.5$

Q7(a)(i)

電路I: $R_{eq} = (\frac{1}{10000} + \frac{1}{10000})^{-1} = 5000\Omega$

$V = IR$

$6 = I(5000 + 10\times10^3)$

$I = 4\times10^{-4}$ A

$V = IR$

$V = (4\times10^{-4})(5000)$

$V = 2V$

∴電路I讀數 2V

II: $R_{eq} = (\frac{1}{10000} + \frac{1}{100})^{-1} = 99.0099099\Omega$

$V = IR$

$6 = I(99.0099099 + 100)$

$I = 0.030149253$ A

$V = IR$

$V = (0.030149253)(99.0099099)$

$V = 2.9850746...$

$\approx 2.99V$

∴電路II讀數 2.99V

Resistance of voltmeter and 10 kΩ resistor

$= \frac{10k\Omega}{2} = 5k\Omega$

Voltmeter reading of circuit I $= 6(\frac{5k\Omega}{(5+10)k\Omega}) = 2V$

$R_{voltmeter + 100\Omega} = \frac{1}{\frac{1}{100} + \frac{1}{10^4}} = 99\Omega$

Voltmeter reading of circuit II $= 6(\frac{99}{99+100}) = 2.98V$

Voltmeter reading for circuit I

$= 6 \times \frac{1}{3}$

$= 2V$

Voltmeter reading for circuit II

$= 6 \times \frac{1}{2}$

$= 3V$

Q7(a)(ii)

The resistance of voltmeter is similar to resistance of the resistors in circuit I. It will dissipate large proportion of energy which leads to inaccurate voltage reading of resistors. We should use a voltmeter with much larger resistance than resistors to measure resistors' resistance.

Because the internal resistance of the voltmeter is very small. So potential difference across the voltmeter is very high.
General principle: Use a voltmeter with a very high internal resistance.

Q7(b)(ii)

$R_{eq} = \frac{10\times10^3 \times 11}{11 + 10000}$

$= 10.99\,\Omega$

$\frac{10.99}{10.011} \times 100\%$

$= 0.11\%$ ✗

total resistance $= \frac{1}{\frac{1}{11} + \frac{1}{10\times1000}} = 10.9879133\,\Omega$

$\frac{10.9879133 - 10}{10} \times 100\%$ ✓ $= 9.88\%$ ✗

8(a)(ii)

$E = \frac{V_0}{d}$ ✓

$3\times10^5 = \frac{V_0}{2\times1000}$, $V_0 = 150\,V$ ✗

$E = \frac{V}{d}$ ✓

$= \frac{3\times10^5}{2}$

$= 150000$ ✗

potential difference $= 3\times10^5\,(2\times10^{-3})$

$= 600\,V$ ✗

Q8(b)(i)

the direction of magnetic field is into paper

$B = \frac{\mu_0 I}{2\pi r}$

$B = \frac{\mu_0 \times 30000}{2\times\pi\times1.5\times1000}$

$B = 40\ Am^{-1}$

8(b)(ii)

When the upward lightning current is increasing, an increasing magnetic field into paper is present. ✓ An induced current flowing anti-clockwise will occur. Later, the upward lightning current decreases, causing a decrease in the magnetic field into paper. ✓ An induced current flowing clockwise will occur.

8(b)(ii)

The magnetic field appears when the lightning strikes. The coil will produce a current and a magnetic field to be against the magnetic field from lightning, which the current is clockwise. After the lightning, the dissappearing magnetic field from lightning makes the coil to produce a magnetic field against the dissappearing magnetic field, thus generating a anti-clockwise current in the coil, by the right hand grip rule.

√ √ X

8(b)(ii)

The lightning generates a magnetic field which leads to an induced current flowing in the certain direction ?

However, by Lenz's law, an induced current flowing in a reverse direction is then produced in order to oppose the change ?

Q8(b)(iii)

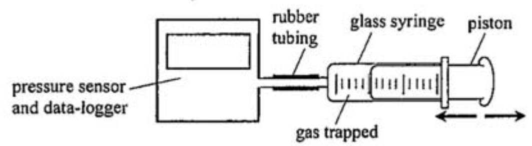
Magnetic field X due to lightning. The other two choices is too strong and high in magnitude that it can damage the equipment and it is difficult to monitor.

大氣中的電場 √ 閃電電流維時極短，不能被監測。磁場有其他干擾，而閃電產生的磁場需近距離監測！否則磁場非常細小，如(bi)，因此電場較龐大，達 3×10^5 NC^{-1}，故監測電場較佳 X

2016 DSE PHYSICS/ COMBINED SCIENCE (PHYSICS)

QUESTION 2 (a)

Figure 2.1



Judy uses the set-up shown in Figure 2.1 to study the relationship between the pressure and volume of a fixed mass of gas at constant temperature. The volume V of the gas trapped is read directly from the syringe and the corresponding pressure p is measured by a data-logger via a pressure sensor.

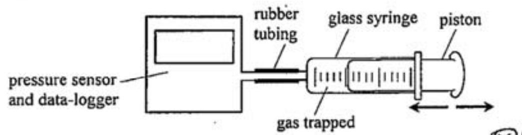
(a) The initial volume and pressure of the gas are 6.0×10^{-5} m^3 and 1.0×10^5 Pa respectively at a room temperature of 25 °C. Estimate the number of gas molecules trapped in the syringe. (3 marks)

QUESTION 2 (a)

Marking Scheme		Performance/ Common Errors
(a) $PV = nRT$	1M	1M for quoting $pV = nRT$
$(1.0\times10^5)(6.0\times10^{-5}) = n\,(8.31)(273+25)$ n = 2.422891 x 10^{-3} moles ≈ 2.42 x 10^{-3} moles	1M	1M for correct sub. Into correct eqn.
The no. of molecules = $n\,N_A$ 1M for 2.42×10^{-3} or nN_A $= n \times 6.02 \times 10^{23}$ $=1.458581 \times 10^{21} \approx 1.46 \times 10^{21}$	1A	Some candidates failed to give the final answer
Alternative method $pV = nRT = \left(\frac{N}{N_A}\right)RT \Rightarrow N = \left(\frac{pV}{RT}\right)N_A$	1M	
$N = \frac{(1.0\times10^5)(6.0\times10^{-5})}{(8.31)(273+25)} \times (6.02\times10^{23})$	1M	
$= 1.458581 \times 10^{21} \approx 1.46 \times 10^{21}$	1A	

QUESTION 2 (a) (SAMPLE)

Figure 2.1



P V T m

Judy uses the set-up shown in Figure 2.1 to study the relationship between the pressure and volume of a fixed mass of gas at constant temperature. The volume V of the gas trapped is read directly from the syringe and the corresponding pressure p is measured by a data-logger via a pressure sensor.

(a) The initial volume and pressure of the gas are 6.0×10^{-5} m^3 and 1.0×10^5 Pa respectively at a room temperature of 25 °C. Estimate the number of gas molecules trapped in the syringe. (3 marks)

$PV = nRT$

$6\times10^{-5} \times 1\times10^{5} = nR(25+273)$ ✓

$n = 2.42\times10^{-3}$ moles 1M

No. of gas molecules ✓ 1M

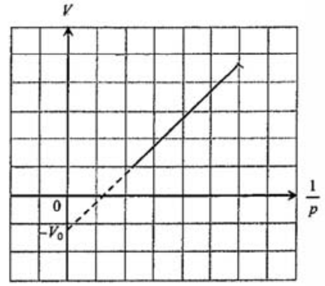
$= n \times N_A$ 1A

$= 1.46 \times 10^{21}$ ✓

QUESTION 2 (b)(i),(ii)

(b) The piston is then pushed in or pulled out to vary V and p such that several pairs of readings are recorded. Figure 2.2 shows the graph of V against $\frac{1}{p}$ plotted.

Figure 2.2



(i) State **ONE** experimental precaution for keeping the gas temperature constant. (1 mark)

(ii) The straight line graph does not pass through the origin but cuts the vertical axis at $-V_0$ instead. Suggest what V_0 stands for. (1 mark)

QUESTION 2 (b)(i),(ii)

Marking Scheme		Performance/ Common Errors
(b) (i) - The piston should be pushed or pulled slowly / lightly. - Avoid taking readings immediately after moving the piston. - The syringe should not be grasped by hand too long (when the piston is pushed in or pulled out). } Any **ONE**	1A 1A 1A	(i) Misconception: The gas temperature could be kept constant by wrapping the syringe with an insulator.
(ii) V_0 - volume of gas trapped in the rubber tubing / space connecting the pressure sensor and syringe.	1A	(ii) Quite a number of candidates wrongly thought that V_0 is the volume of gas at absolute zero or under infinite pressure

QUESTION 2 (b)(i),(ii) (SAMPLE)

(i) 說出實驗中的一個預防措施使氣體的溫度保持恆定。 (1 分)

拉出或推入活塞时动作应缓慢。 ✓ 1A

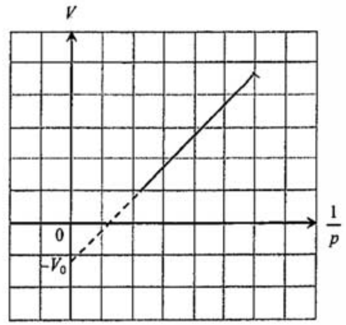
(ii) 直線線圖並沒有穿過原點，而是與豎直軸相交於 $-V_0$。試指出 V_0 代表什麼。 (1 分)

被困气体体积 ✗ 0A

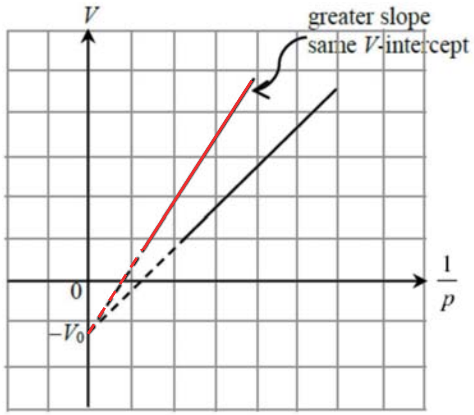
QUESTION 2 (b)(iii)

(iii) If the experiment is repeated at a higher room temperature using this set-up with the same mass of the same gas, sketch the expected graph in Figure 2.2. (2 marks)

Figure 2.2



QUESTION 2 (b)(iii)

Marking Scheme	Performance/ Common Errors
	1A+1A No mark for a curve Well answered

QUESTION 2 (b)(iii) (SAMPLE)

(b) 將活塞推入或拉出以改變 V 和 p，從而錄取多對數據。圖 2.2 顯示所標繪的 V 對 $\frac{1}{p}$ 線圖。

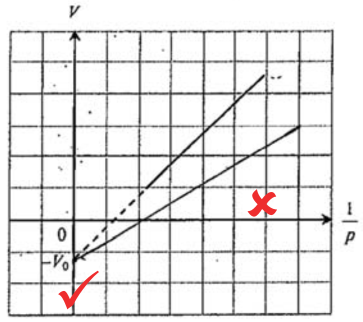


圖 2.2

(iii) 如果在較高室溫下用這裝置以相同質量的同一氣體進行實驗，在圖 2.2 草繪預期的線圖。 (2 分)

QUESTION 6 (a)(i),(ii)

*6. (a) A laser beam is directed perpendicularly towards a double slit of separation $a = 0.3$ mm. The pattern of bright spots projected on a screen 1.8 m away from the slits is shown in Figure 6.1.

Figure 6.1

(i) Find the wavelength of the laser beam. (3 marks)

(ii) Explain why the slit width has to be very narrow in order for the above pattern to be observed. (2 marks)

QUESTION 6 (a)(i),(ii)

Marking Scheme		Performance/ Common Errors
(a) (i) $\Delta y = \frac{\lambda D}{a}$ $\frac{(4.0-0)\times 10^{-2}}{10} = \frac{\lambda(1.8)}{0.3\times 10^{-3}}$	1M+1M	Mistake in getting the fringe separation The range of Δy: 3.6×10^{-3} to 4.2×10^{-3} m
$\lambda = 6.666667\times10^{-7}$ m $\approx 6.67\times10^{-7}$ m or 667 nm	1A	The value of λ: 600 nm to 700 nm
(ii) To ensure that the light through the 2 slits diffracts enough to interfere / overlap.	1A 1A	Explanation in terms of formula $\lambda = \Delta y\frac{a}{D}$ is NOT accepted as a is the slit separation given, which is fixed. Confused slit width with slit separation

QUESTION 6 (a)(i)(ii) (SAMPLE)

*6. (a) A laser beam is directed perpendicularly towards a double slit of separation $a = 0.3$ mm. The pattern of bright spots projected on a screen 1.8 m away from the slits is shown in Figure 6.1.

Figure 6.1

ruler with cm scale marks

(i) Find the wavelength of the laser beam. (3 marks)

$\Delta y = \frac{\lambda D}{a}$ 0M

$1 \times 10^{-3} = \frac{\lambda (1.8)}{3 \times 10^{-4}}$ 1M

0A

$\lambda = 1.67 \times 10^{-7}$ m

(ii) Explain why the slit width has to be very narrow in order for the above pattern to be observed. (2 marks)

very narrow slit is used to make the effect of diffraction more apparent, to let light do the interference. 1A 1A

QUESTION 6 (b)(i)

(b) The double slit is now replaced by a diffraction grating of 500 lines per mm.

(i) Find the separation between the central bright spot and first-order bright spot of the pattern on the screen for the same experimental settings. (3 marks)

QUESTION 6 (b)(i)

Marking Scheme		Performance/ Common Errors
(b) (i) $d \sin\theta = m\lambda$		
$\frac{10^{-3}}{500} \sin\theta = 6.67 \times 10^{-7}$ m	1M	1M for correct method to find θ
$\theta = 19.471221° \approx 19.47°$ $\Delta y = \frac{\lambda D}{a}$		
Separation between central and first-order bright spot $= 1.8 \tan 19.47°$	1M	Some candidates wrongly applied $\Delta y = \frac{\lambda D}{a}$ to find the separation
$= 0.636396 \text{ m} \approx 0.636$ m	1A	

QUESTION 6 (b)(i) (SAMPLE)

(b) The double slit is now replaced by a diffraction grating of 500 lines per mm.

(i) Find the separation between the central bright spot and first-order bright spot of the pattern on the screen for the same experimental settings. (3 marks)

$d \sin\theta = n\lambda$

$\frac{10^{-3}}{500} \times \sin\theta = \lambda$ 1M

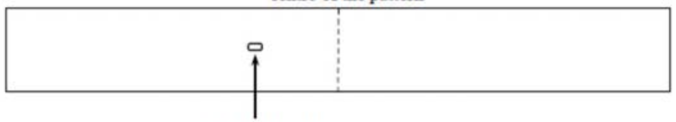
1M

$\theta = 4.78°$ 0A

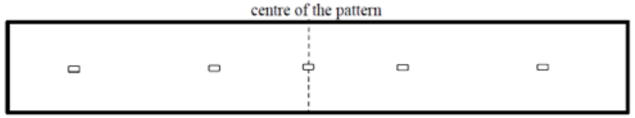
∴ the separation = $1.8 \times \tan\theta$ = 0.151 m

QUESTION 6 (b)(ii)

(ii) Sketch the pattern, up to the second-order, that you would expect to see on the screen when using this diffraction grating. A first-order bright spot has already been drawn for you. (2 marks)

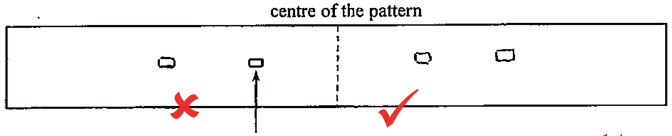


QUESTION 6 (b)(ii)

Marking Scheme	Performance/ Common Errors
(ii)  symmetry about the central bright spot 1A; separation between 2[nd] and 1[st] -order bright spots is larger 1A; Note: For 2[nd] order, 41.81° & 1.610 m	Performance was poor

QUESTION 6 (b)(ii) (SAMPLE)

(ii) Sketch the pattern, up to the second-order, that you would expect to see on the screen when using this diffraction grating. A first-order bright spot has already been drawn for you. (2 marks)



QUESTION 9 (a),(b)(i)

9. Part of the decay series of uranium-238 (U-238) is shown below. The end product lead-206 (Pb-206) is stable.

$$^{238}_{92}\text{U} \xrightarrow[4.5\times10^{9}\text{ years}]{\alpha} \text{Th} \xrightarrow[21\text{ days}]{\beta} \text{Pa} \rightarrow \ldots \rightarrow {}^{206}_{82}\text{Pb}$$

(a) When a U-238 nucleus decays to a Pb-206 nucleus, how many α-particle(s) and β-particle(s) are emitted ? (2 marks)

(b) As the first decay in the above chain from U to Th has a half-life much longer than those of subsequent decays, the decay from U-238 to Pb-206 can be simplified to *a single decay* with half-life 4.5×10^{9} years:

$$^{238}_{92}\text{U} \xrightarrow[4.5\times10^{9}\text{ years}]{} {}^{206}_{82}\text{Pb}$$

Suppose that a uranium-bearing rock contains only U-238 and no Pb-206 at the time when it was formed long ago by solidification of molten material. In a particular sample of the rock, it is found that the ratio $\frac{\text{number of Pb-206 atoms}}{\text{number of U-238 atoms}}$ is $\frac{2}{3}$ *at present.*

(i) Estimate the age of the rock. Assume that all Pb-206 atoms come from the decay of U-238 originally present in the sample and ignore the small number of U-238 atoms which have decayed but have not yet become Pb-206. (2 marks)

QUESTION 9 (a),(b)(i)

Marking Scheme		Performance/ Common Errors
(a) $(4)n_\alpha = 238 - 206 \Rightarrow n_\alpha = 8$	1A	(a) Well answered
$(2)n_\alpha + (-1)n_\beta = 92 - 82 \Rightarrow n_\beta = 6$	1A	
(b) (i) $N = N_0\left(\frac{1}{2}\right)^{t/T_{1/2}}$ $\frac{3}{5}N_0 = N_0\left(\frac{1}{2}\right)^{t/4.5\times10^9\,\text{yr}}$	1M	Unable to obtain the ratio 3/5
Or $N = N_0 e^{-\lambda t}$ and $\lambda = \frac{\ln 2}{T_{1/2}}$	1M	
$\therefore t = 3.316\times10^9$ years $\approx 3.3\times10^9$ years	1A	

QUESTION 9 (a) (SAMPLE)

9. 鈾-238 (U-238) 的連串衰變其中一部分顯示如下，而最終產物鉛-206 (Pb-206) 是穩定的。

$$^{238}_{92}U \xrightarrow[4.5\times10^9\text{ 年}]{\alpha} Th \xrightarrow[21\text{日}]{\beta} Pa \rightarrow \ldots \rightarrow {}^{206}_{82}Pb$$

(a) 當一個 U-238 原子核衰變成一個 Pb-206 原子核時，會發射出多少個 α 粒子和 β 粒子？ (2 分)

$^{238}_{92}U \longrightarrow {}^{206}_{82}Pb + n\,{}^4_2He + m\,{}^0_{-1}e$

$4n + 206 = 238$

$n = 8$ ✓ 1A

$92 = 82 + 8\times2 - m$ 1A

$m = 6$ ✓

∴ 放出 6 β粒子 8个α粒子

QUESTION 9 (b)(i) (SAMPLE)

(b) 在以上連串衰變中，首項從 U 至 Th 的衰變的半衰期遠較隨後各衰變的半衰期長，因此從 U-238 至 Pb-206 的衰變可簡化成半衰期為 4.5×10^9 年的單一衰變：

$$^{238}_{92}U \xrightarrow[4.5\times10^9\text{ 年}]{} {}^{206}_{82}Pb$$

假設有一含鈾的石塊，在很久前由熔融物質凝固而成時只含 U-238 而並無 Pb-206。在石塊的某樣本中找到現時 $\frac{\text{Pb-206 原子的數目}}{\text{U-238 原子的數目}}$ 的比例為 $\frac{2}{3}$。 $\frac{3}{5}$ $\frac{2}{5}$

(i) 估算石塊的年齡。假設所有的 Pb-206 原子皆源於當初在樣本中的 U-238 經歷衰變所產生，並可忽略少量已衰變但仍未變成 Pb-206 的 U-238 原子。 (2 分)

$1\times\left(\frac{1}{2}\right)^n = \frac{3}{5}$

$n = \frac{\ln\frac{3}{5}}{\ln\frac{1}{2}} = 0.73695594$ ✓ 1M

石塊年齡 $= 0.73695594\times4.5\times10^9$

$= 3.32\times10^9$ 年 ✓ 1A

QUESTION 9 (b)(ii)

(ii) State, with a reason, whether the answer in (b)(i) is an overestimate or an underestimate of the age of the rock if some Pb-206 atoms have actually been lost. (2 marks)

QUESTION 9 (b)(ii)

Marking Scheme		Performance/ Common Errors
(ii) Answer in (i) is an <u>underestimate</u>. The original number of U-238 atoms should be greater.	1A	Reason is not concise
$\therefore$ the ratio $\dfrac{\text{present number of U}-238\text{ atoms}}{\text{original number of U}-238\text{ atoms}} = \dfrac{N_t}{N_0}$ is in fact smaller (than $\dfrac{3}{5}$), thus longer time should have been elapsed.	1A	

QUESTION 9 (b)(ii) (SAMPLE)

(ii) 如果部分的 Pb-206 原子實際上已流失了，指出 (b)(i) 部的答案是高估了還是低估了石塊的年齡，並給出理由。 (2 分)

低估了，U-238衰变数目多于~~原本~~(b)(i) ✓ 1A

~~至~~石块衰变时间变长。 ✓ 1A

QUESTION 9 (b)(iii)

(iii) The graph in Figure 9.1 shows how the number of U-238 atoms in the sample varies with time t subsequently while $t = 0$ denotes *the present time*. On Figure 9.1, sketch a graph to show the variation of the number of Pb-206 atoms in the sample with time. (2 marks)

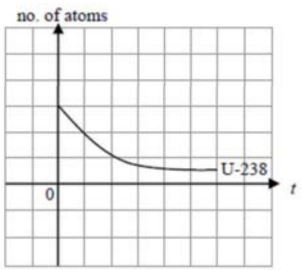
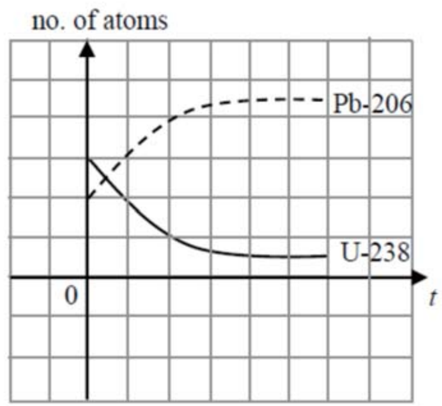


Figure 9.1

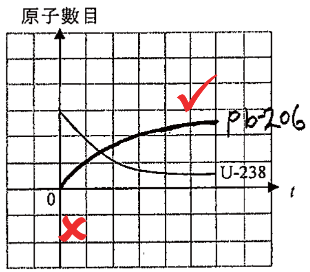
QUESTION 9 (b)(iii)

Marking Scheme	Performance/ Common Errors
(iii) 	Accept convex in shape 1A complementary shape 1A all correct Only a few candidates realized that the number of Pb-206 atoms is non-zero at $t = 0$

QUESTION 9(b)(iii) (SAMPLE)

(iii) 圖 9.1 的線圖顯示樣本中 U-238 原子的數目往後怎樣隨時間 t 變化，而 $t = 0$ 代表現時。在圖 9.1 草繪一線圖以顯示樣本中 Pb-206 原子的數目隨時間的變化。 (2 分)

圖 9.1



1A

0A

THANK YOU!

Paper 2

Section A: Astronomy and Space Science

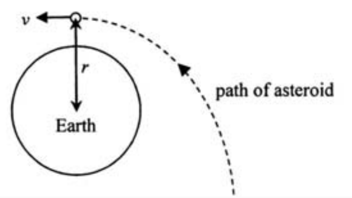
Q.1 Multiple-choice questions

	A	B	C	D
1.1	7.25	**71.08***	9.19	11.20
1.2	9.70	19.77	**48.32***	20.61
1.3	**53.35***	9.70	17.25	17.91
1.4	9.92	12.30	**56.52***	19.58
1.5	8.24	9.00	12.15	**68.48***
1.6	13.26	**52.95***	23.62	7.76
1.7	**37.52***	12.99	17.13	30.12
1.8	14.39	29.90	16.22	**37.19***

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

MC 1.2

An asteroid (mass m) approaches the Earth (mass $M >> m$) as shown. The velocity at the closest approach is v and the corresponding distance from the Earth's centre is r. Assuming no energy is lost during the asteroid's journey, what is its kinetic energy when it is very far away from the Earth ?



A. 0

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

C. $\frac{1}{2}mv^2 - \frac{GMm}{r}$ *48.32%

D. $\frac{1}{2}mv^2 + \frac{GMm}{r}$ 20.61%

MC 1.7

- Star X and Y are equal brightness to the naked eye. The measured parallax of stat X is twice that of star Y. What is the ratio (luminosity of X)/(luminosity of Y)

A. $\frac{1}{4}$ *33.72%

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

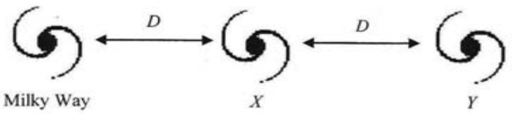
C. 2

D. 4 30.12%

luminosity = total power emitted , parallax $\propto$ 1/stellar distance.
Inverse square law.

MC 1.8

Three galaxies are separated by distance D as shown below. The H_α line of Galaxy X when observed from the Milky Way shows a red shift of $\Delta\lambda$.



Which of the following statements is/are correct ?

(1) The H_α line of Galaxy Y when observed from the Milky Way shows a red shift greater than $\Delta\lambda$.
(2) The H_α line of the Milky Way when observed from Galaxy X shows no red shift.
(3) The speed at which Galaxy X is moving away from Galaxy Y equals the speed of which Galaxy X is moving away from the Milky Way.

A. (2) only
B. (3) only 29.90%
C. (1) and (2) only
D. (1) and (3) only *37.19%

- $v = Hd$
- No centre of expansion

Q1 Structured Question

(a) Explain qualitatively how **absolute magnitude, apparent magnitude** and **luminosit**y of a star are related.

Apparent magnitude is a measure of brightness and it depends on (star's) *luminosity* and distance from the Earth. 1A
If distance *D* is fixed (at 10 pc), it is called *absolute magnitude* which then depends only on *luminosity*. 1A

One mark for each relation
Accept any two relations between:
Absolute magnitude and luminosity (M and L)
Apparent magnitude and luminosity (m and L)
Absolute magnitude and Apparent magnitude (M and m)

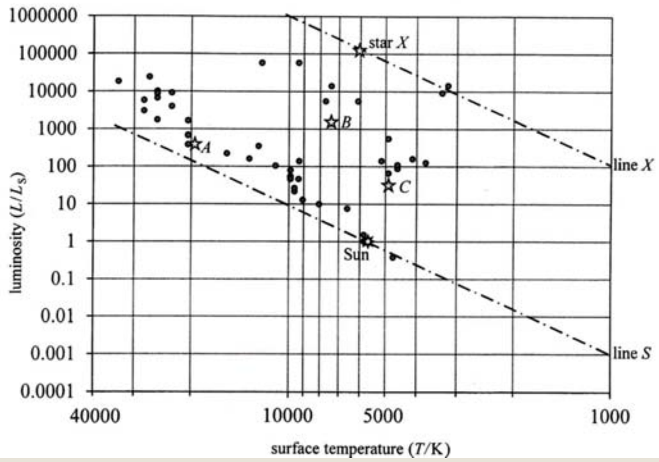
- Accept:
- L increases, M decreases
- "Intensity" or "flux" in lieu of "brightness" if there is no ambiguity of the meaning $L/4\pi d^2$
- $M = m - 5 \log (d/10)$ [It relates M and m] or $M = m + 5 \log (d/10)$
- Absolute magnitude is the apparent magnitude when the distance is 10 pc [It relates M and m]

NOT accept:
- answers which are simply statement or definition of apparent magnitude, absolute magnitude or luminosity and have no linkage between (apparent or absolute) magnitude and luminosity.
- e.g apparent magnitude is the brightness of a star observed on Earth [It only relates magnitude and brightness. It does not relate brightness and luminosity]

- L increases, m decreases [The distance is not fixed in apparent magnitude]
- L is inversely proportional to M
- M is inversely proportional to L
- M is proportional to L
- m is proportional to M
- L is proportional to m
- M increases, L increases
- M or m is the energy received ….
- 「光亮」[It mixes up brightness 亮度and luminosity 光度]

Candidates had difficulty in explaining the relationship of absolute magnitude, apparent magnitude and luminosity of a star in (a). Most of them just simply stated the meaning of each of the terms.

The Hertzsprung-Russell diagram (HR diagram) below shows the 50 brightest stars as seen from the Earth.



(b) (i) L, R and T are the luminosity, radius and surface temperature of a star. Use Stefan's law to show that

$$\frac{L}{L_S} = \left(\frac{R}{R_S}\right)^2 \left(\frac{T}{T_S}\right)^4$$

where L_S, R_S and T_S are the luminosity, radius and surface temperature of the Sun. State an assumption you made. (2 marks)

$L = 4\pi R^2 \sigma T^4$

$L_S = 4\pi R_S^2 \sigma T_S^4$ 1M

Assume that the Sun and the star are black bodies. 1A

(ii) Star X in the HR diagram has surface temperature $T = 6100$ K and luminosity $L = 126000\, L_S$. Find the radius R of star X in terms of the Sun's radius R_S. Hence name the type of star that it belongs to. Given: surface temperature of the Sun $T_S = 5840$ K. (3 marks)

$$\frac{R}{R_S} = \left(\frac{L}{L_S}\right)^{1/2} \left(\frac{T_S}{T}\right)^2$$

$\frac{R}{R_S} = (126000)^{1/2} \times \left(\frac{5848}{6100}\right)^2$ 1M

$R = 325.350364\ R_S \approx 325\ R_S$, 1A

X is a (super)giant 1A

It is a yellow supergiant but we accept all answers containing 'giant', such as supergiant, giant, red giant etc.

Part (b) was well answered although not many mentioned the correct assumption that both celestial bodies are taken as black bodies.

(c) (i) Taking the logarithm of the equation in (b)(i) yields the following equation:

$$\log\left(\frac{L}{L_S}\right) = 4\log T + 2\log\left(\frac{R}{R_S}\right) - 4\log T_S$$

Show that it represents *a straight line* in the HR diagram and all stars on the line are of *the same size*. The scales on both axes of the HR diagram are logarithmic and the x-axis indicates a higher temperature towards the left. R_S and T_S are constants. [Note: Line S and line X in the diagram are two such straight lines running from upper left to lower right containing the Sun and star X respectively.] (2 marks)

$$\log\left(\frac{L}{L_S}\right) = 4\log T + 2\log\left(\frac{R}{R_S}\right) - 4\log T_S$$

$y = \log\frac{L}{L_S}$; $x = \log T$; $m = 4$

It takes the form of a straight line $y = mx + c$ 1A

and the y-intercept c is determined by the star radius R 1A

[Note: $c = +2\log\left(\frac{R}{R_S}\right) - 4\log T_S$,R_S & T_S are constants]

(ii) For stars A, B and C in the HR diagram, deduce which one is the largest. (1 mark)

B (largest) 1A

In (c)(i), stronger candidates were able to relate the terms of the equation given with those of an equation of a straight line $y = mx + c$. Most performed well in (c)(ii).

Paper 2

Section B : Atomic World

Q.2 Multiple-choice questions

	A	B	C	D
2.1	8.70	40.41	**33.99**	16.54
2.2	33.31	8.72	7.46	**50.26**
2.3	13.14	19.72	**56.67**	10.12
2.4	24.35	**55.63**	4.88	14.82
2.5	21.73	**45.76**	18.06	13.68
2.6	5.03	14.33	28.17	**51.89**
2.7	**49.37**	26.04	7.38	16.90
2.8	**32.17**	29.33	28.15	10.09

Bold : Key ; Red colour : Most favorable distractor

Q.2 Multiple-choice questions

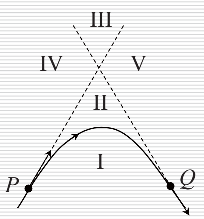
2.1 In the above figure, the solid line is the trajectory of an α-particle scattered by a gold nucleus (not shown in figure). The dotted lines are tangents to the trajectory at points *P* and *Q*. The two dotted lines together with the trajectory divide the plane into five regions (I – V). In which region(s) can the gold nucleus be situated ?

A. I (8.70%)

B. II (40.41%)

C. III **(33.99%)***

D. IV OR V (16.54%)



Q.2 Multiple-choice questions

2.2 Which statements about *wave-particle duality* are correct ?

(1) Interference of light is evidence that light behaves as a wave.

(2) Photoelectric effect is evidence that light behaves as a particle.

(3) Electron diffraction by a crystal shows that electrons behave as a wave.

A. (1) and (2) only (33.31%)

B. (1) and (3) only (8.72%)

C. (2) and (3) only (7.46%)

D. (1), (2) and (3) **(50.26%)***

Electron diffraction is a topic under “wave-particle duality”

Q.2 Multiple-choice questions

2.5 If the de Broglie waves associated with a proton and an α-particle have the same wavelength, what is the ratio of the kinetic energy of the proton to that of the α-particle ?

A. 1 : 4 (21.73%)
B. 4 : 1 **(45.76%)***
C. 1 : 2 (18.06%)
D. 2 : 1 (13.68%)

Same wavelength → same momentum
K.E. = $p^2/2m$
→ ratio of K.E. is inversely proportional to $1/m$.
Poor mathematical deduction.
Wrongly thought that mass of α-particle is 2 times mass of proton

Q.2 Multiple-choice questions

2.7 Transmission electron microscope (TEM) is used to observe structures of nano-scale instead of an optical microscope. This is because electron wave compared to visible light can have

A. shorter wavelength so that its diffraction is less significant. **(49.37)***
B. shorter wavelength so that its diffraction is more significant. (26.04%)
C. longer wavelength so that its diffraction is less significant. (7.38%)
D. longer wavelength so that its diffraction is more significant. (16.90%)

Concept about microscope/diffraction is poor.

Q.2 Multiple-choice questions

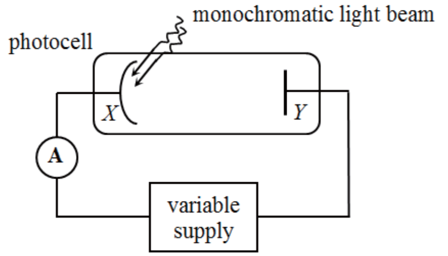
2.8 Which of the following applications in nanotechnology utilize(s) **Lotus effect** ?

(1) Water-repelling fabric used in swimming suits is manufactured by nano-coating.
(2) Glass is made self-cleaning by coating it with a water-attracting material in nanoscale.
(3) Nano-sized zinc oxide is added to fabric as a photocatalyst for protection from dirt.

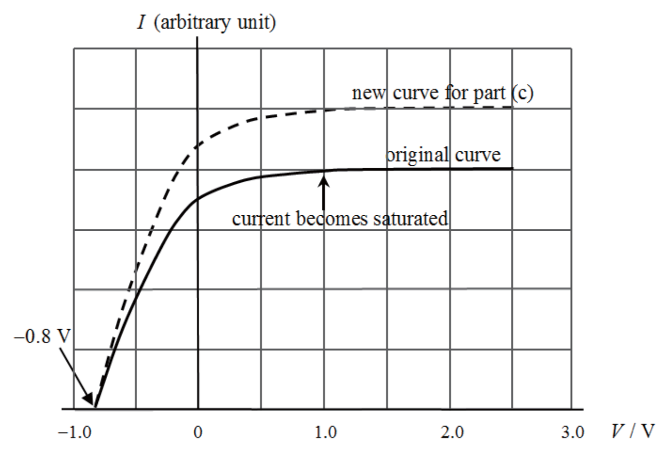
A. (1) only **(32.17%)***
B. (1) and (2) only (29.33%)
C. (1) and (3) only (28.15%)
D. (2) and (3) only (10.09%)

Q.2 Structured question

Figure 2.1



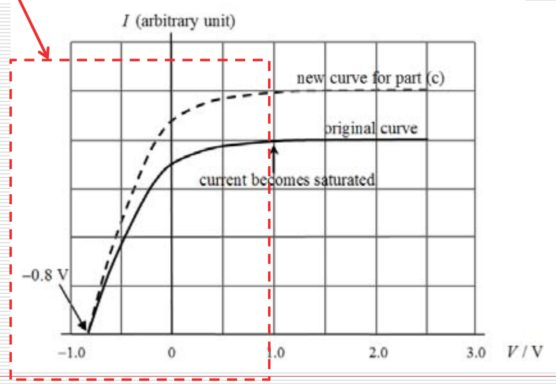
The set-up in Figure 2.1 is for the study of the photoelectric effect. A monochromatic light beam with each photon of energy 3.4 eV is directed towards the photo-sensitive cathode X of a photocell. The potential difference V across anode Y and cathode X can be changed by adjusting the variable supply. The graph shows how the photoelectric current I varies with the potential difference V.



Q.2 Structured question

(a) (i) The photoelectric current I becomes saturated after V reaches a certain value. Explain why this is so. (1 mark)

All photoelectrons emitted (from X) can reach Y.



Q.2 Structured question

(a) (i) The photoelectric current I becomes saturated after V reaches a certain value. Explain why this is so. (1 mark)

Or Maximum number of photoelectrons emitted is limited by intensity of light.

Or Limited number of photoelectrons is produced each second.

Common mistakes

Mixed up cathode and anode.

Try to explain the electrons escape from metal instead of electrons from cathode to anode.

Q.2 Structured question

(a) (ii) Hence deduce the *maximum kinetic energy*, in eV, of the photoelectrons reaching anode Y when I is just saturated. (2 marks)

Maximum k.e. reaching anode Y = (0.8 +1.0) eV 1M
= 1.8 (eV) 1A

Most of the candidates were not aware that the saturation current occurs at a voltage of 1.0 V (which is larger than 0 V) and depends on the structure of the photocell.

Common wrong answers : 0.8 eV, 1 eV (read directly)
2.4 eV or 2.6 eV (3.4 – 1 or 3.4 – 0.8)

Q.2 Structured question

(b) (i) Find the work function, in eV, of the metal of cathode *X* and calculate the threshold wavelength for this metal. (3 marks)

$3.4 = \Phi + 0.8 \Rightarrow \Phi = 2.6$ (eV) 1A

Some candidates used the result in (a)(ii) as the work function.
Quite a lot of them could not differentiate maximum kinetic energy, work function and stopping potential.

Q.2 Structured question

(b) (i) Find the work function, in eV, of the metal of cathode *X* and calculate the threshold wavelength for this metal. (3 marks)

$3.4 = \Phi + 0.8 \Rightarrow \Phi = 2.6$ (eV) 1A

$\frac{hc}{\lambda} = \Phi \Rightarrow \lambda = \frac{(6.63\times10^{-34})(3.0\times10^{8})}{(2.6)(1.60\times10^{-19})}$

$\lambda = 4.78125 \times 10^{-7}$ m ≈ 478 nm

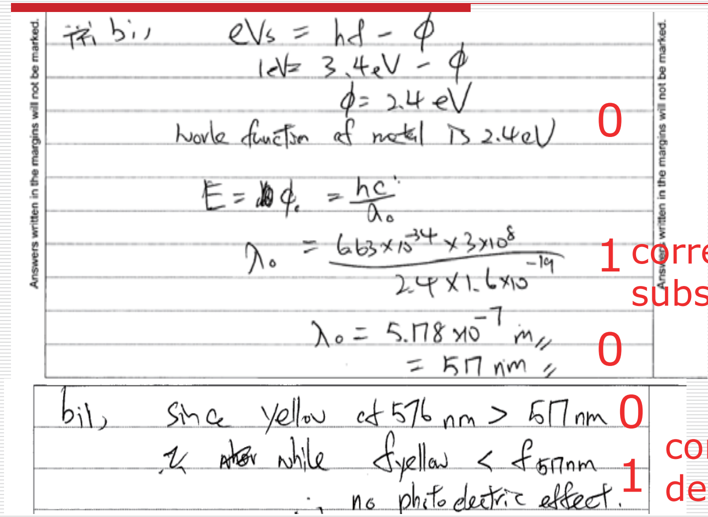
Most candidates can apply $\lambda = hc/\Phi$ to find λ but some of them forgot to convert eV to joule and some just found threshold frequency instead of threshold wavelength λ.

Q.2 Structured question

(b) (ii) Hence explain whether yellow light of wavelength 576 nm can have photoelectric effect on cathode *X*. (2 marks)

No, 1A
as λ_{yellow} = 576 nm (≈2.16 eV) > 478 nm (≈2.6 eV). 1M
(Accept comparing frequency or energy)

Most of the candidates knew that the larger the wavelength, the lower the energy of the source and deduced a correct conclusion.



0
1 correct substitution
0
0
1 correct deduction

案，將不予評閱。 Answers written in the margins will not be marked.

b i) [illegible] $KE_{max} = hf + \phi$

$1.6\times10^{-18} = 1.28\times10^{-17} + \phi$ 0

$\phi = 3.2\times10^{-20}$

$\phi = hf$

$f = 4.83\times10^{13}$ 1

$c = \lambda_0 f$

$\therefore 3\times10^{8} = \lambda_0 f$

$\lambda_0 = 6.21\times10^{-6}$ m 0

b ii) $\because$ wavelength of yellow light = 576 nm = 5.76×10^{-11} m < 6.21×10^{-6} m 0

$\therefore f_{yellow\ light} > f_0$ 1 correct deduction

$\therefore$ There is photoelectric effect.

Q.2 Structured question

(c) If the experiment is repeated with another light beam using the same photocell, a new curve (in dotted line) is obtained as shown. What can be said about this light beam's frequency and intensity ? (2 marks)

This light beam is more intense but with the same frequency as the original one. 1A

Well answered but still some candidates wrongly thought that the frequency will change.

Paper 2

Section C : Energy and Use of Energy

Q.3 Multiple-choice questions

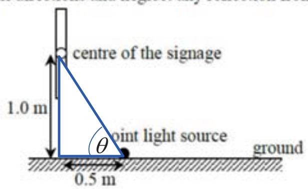
	A	B	C	D
3.1	16.50	**59.18***	17.46	6.70
3.2	**26.00***	31.76	32.01	9.42
3.3	16.32	2.37	**75.87***	5.35
3.4	10.25	**47.62***	33.12	8.72
3.5	**40.63***	6.68	4.01	48.54
3.6	21.74	14.00	11.26	**52.74***
3.7	28.56	4.77	**60.60***	5.79
3.8	9.41	35.11	**46.38***	8.96

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

MCQ 3.2

3.2 The signage below is to be illuminated by a point light source from the ground as shown. What is the luminous flux of the source required for producing an illuminance of 200 lux at the centre of the signage ? Assume that the source emits light uniformly in all directions and neglect any reflection from the ground.

signage



*	A.	7025 lm	26.00%
	B.	3512 lm	
	C.	3142 lm	favourable distractor 32.01%
	D.	560 lm	

A B C D

$$200 = \frac{\Phi}{4\pi(0.5^2+1^2)} \times \frac{0.5}{\sqrt{0.5^2+1^2}}$$

$$E = \frac{\Phi}{4\pi r^2}\cos\theta$$

$$\Phi = 3142 \times \frac{\sqrt{0.5^2+1^2}}{0.5}$$

$$= 7025 \text{ lm}$$

MCQ 3.4

3.4 Which statement about a solar cell is **INCORRECT** ?

A. When sunlight shines on a solar cell, some electrons in the semiconductor are excited to be free electrons.

* B. When a solar cell delivers power, current only flows in the interface at the p-n junction. 47.62%

C. The output voltage of a solar cell remains more or less unchanged when the incident light intensity increases. favourable distractor 33.12%

D. The efficiency of typical solar cells is about 10% to 20%.

A B C D

Many candidates thought that the output voltage will increase when the light intensity increases.

MCQ 3.5

3.5 A room is cooled down by an air-conditioner and maintained a steady temperature which is ΔT below the temperature outside. Which of the factors below would affect ΔT ?

(1) thermal conductivity of the wall material of the room
(2) cooling capacity of the air-conditioner
(3) specific heat capacity of air

* A. (1) and (2) only — 40.63%
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3) — favourable distractor — 48.54%

A B C D

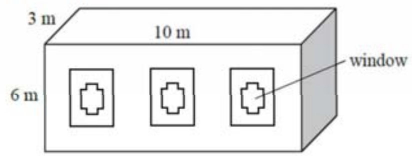
rate of heat gain = rate of heat loss

$$\frac{\kappa A \Delta T}{d} = \text{cooling capacity}$$

ΔT is independent of the specific heat capacity of air.

MCQ 3.8

3.8 The Overall Thermal Transfer Value (OTTV) of the house shown is 25 W m^{-2} and the rate of heat generated due to human activities inside is 2000 W. Which cooling capacity below for an air-conditioning system is the **most appropriate** choice for the house ?



A. 2 kW
B. 5 kW — favourable distractor — 35.11%
* C. 10 kW — 46.38%
D. 15 kW

A B C D

$$\text{rate of heat transfer} = \text{OTTV} \times \text{Total surface area}$$
$$= 25 \times 186$$
$$= 4650 \text{ W}$$

Many candidates did not consider the heat generated due to human activities.

Q.3 Structured question

Figure 3.1 shows a wind power station backed up by a pumped hydroelectric storage system via a control centre. Excess electrical power from the wind farm can be used to pump water from the lower reservoir to the upper one during off-peak hours. During peak hours, water runs down from the upper reservoir to drive the turbine and generator to produce electricity.

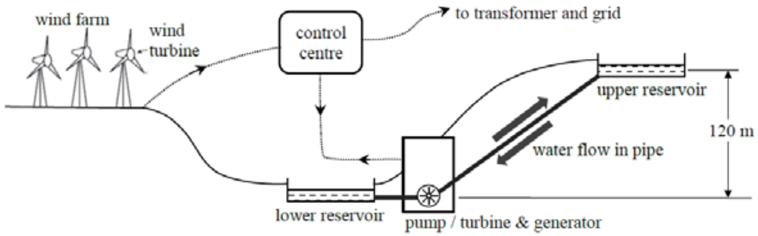


Figure 3.1

A rotor blade of each wind turbine is 30 m long. Each turbine can be automatically controlled so that the blades' rotational plane is always normal to the wind direction. The graph in Figure 3.2 shows how the electrical power output from each turbine varies with wind speed.

Q.3 Structured question

(a) (i) State the reason why practically there is no power output from the turbine when the wind speed is (I) lower than 5 m s^{-1}; and (II) higher than 25 m s^{-1}. (2 marks)

Friction between contact surfaces is too large which cannot be overcome by the wind at such speed. 1A

Not accept: "force is not large enough" or "mass of the turbine is too large"

The turbine is automatically locked and stopped, otherwise the strong wind may damage the blades. 1A

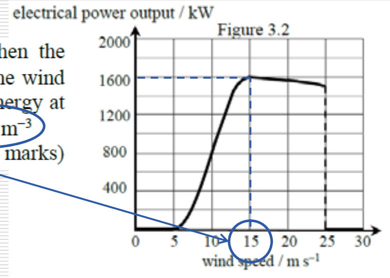
Not accept: "the turbine was damaged", "the turbine cannot work under strong wind" or "the turbine cannot withstand strong wind"

Q.3 Structured question

- In (a)(i), most candidates mentioned that the turbine will not move when the wind speed is too low, but few of them pointed out that it is due to the friction between the contact surfaces.
- Some candidates knew that the turbine will be damaged when the wind speed is high, however, not many went on to elaborate that the turbine is actually shut down to prevent such damage.

Q.3 Structured question

(ii) The turbine attains maximum power output when the wind speed is 15 m s^{-1}. Find the efficiency of the wind turbine in converting wind energy to electrical energy at such wind speed. Given: density of air = 1.23 kg m^{-3} (2 marks)



$P = \frac{1}{2}\rho A v^3 \times \eta$ 1M

1600×10^3 W = $\frac{1}{2} \times 1.23$ kg m$^{-3} \times \pi$ (30 m)$^2 \times$(15 m s^{-1})$^3 \times \eta$

η = 27.3 % 1A

- Part (a)(ii) was well answered.

Q.3 Structured question

(b) There are 50 wind turbines in the wind farm for supplying electricity to a town. Figure 3.3 shows the variation of the town's electrical power demand with time of a day.

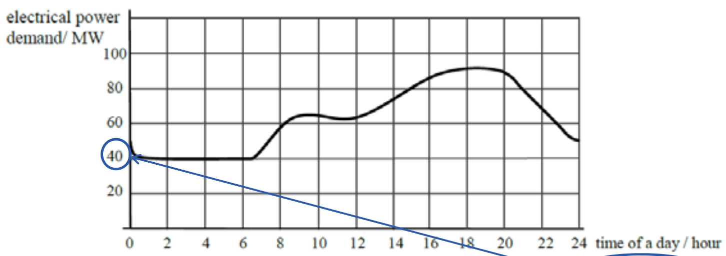


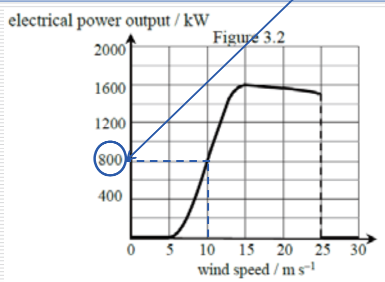
Figure 3.3

(i) Using the two graphs given, find the lowest wind speed needed to meet the town's minimum demand of electrical power in a day without using the pumped hydroelectric storage system. (2 marks)

Power required from one turbine = $\frac{40 \times 10^6}{50}$ = 0.8 MW 1M/1A

Q.3 Structured question

Power required from one turbine = $\frac{40 \times 10^6}{50}$ = 0.8 MW 1M/1A

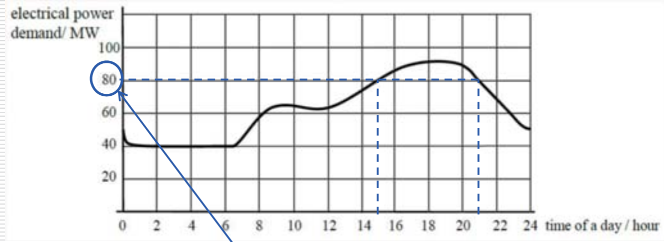


From the graph, wind speed needed is 10 m s^{-1}. 1A

Q.3 Structured question

- In (b)(i), many took it for granted that the efficiency of the wind turbine remains the same at different wind speeds. Instead of finding the required wind speed from the graph provided, they tried to calculate the 'expected' wind speed by using an incorrect efficiency.

Q.3 Structured question



(ii) Suppose that on a certain day the wind speed is always 15 m s^{-1}.

(I) Estimate the total power output of the wind farm. Hence state the time period within which the pumped hydroelectric storage system needs to generate electricity for the town. (2 marks)

1600 kW x 50 = 80000 kW or 80 MW	1M/1A
From the graph (>80 MW), 15:00 – 21:00	1A

Q.3 Structured question

- In (b)(ii)(I), most candidates were able to calculate the total output power of the wind farm, but some failed to relate it precisely with the time period within which the pumped hydroelectric storage system needs to generate electricity.

Q.3 Structured question

1600 kW x 50 = 80000 kW or 80 MW	1M/1A

(II) During the period of minimum demand of electrical power by the town, at what flow rate, in kg s^{-1}, is water in the lower reservoir pumped back to the upper one at a vertical height of 120 m? The overall efficiency of the pump is 80%. (g = 9.81 m s^{-2}) (2 marks)

(80 – 40) x 10^6 W x 80 % = m x 9.81 m s^{-2} x 120 m	1M
m = 2.7183 x 10^4 (kg s^{-1})	1A

- In (b)(ii)(II), quite a number of them mixed up the pump's input power and output power, and as a result employed an incorrect expression of efficiency in the calculation.

Paper 2

Section D: Medical Physics

HKDSE 2016

Multiple Choice

Qn.	1	2	3	4	5	6	7	8
A	**47.9%**	**46.4%**	7.9%	10.9%	16.1%	11.9%	10.3%	7.0%
B	31.2%	21.5%	15.5%	7.1%	**49.4%**	**45.5%**	26.3%	16.0%
C	9.1%	21.6%	21.5%	**66.2%**	20.7%	18.9%	14.9%	24.4%
D	11.5%	10.1%	**54.8%**	15.7%	13.4%	23.6%	**48.3%**	**52.6%**

Bold : Key ; Red colour : Most favorable distractor

Qn. 4.1

4.1 The retina contains two types of light sensitive cells, namely, rods and cones. Which of the following statements about rods and cones is/are correct ?

(1) Rods are responsible for vision at low light levels.
(2) Rods are less numerous than cones.
(3) Both rods and cones are capable of colour vision.

*A. (1) only
B. (1) and (2) only
C. (2) and (3) only
D. (1), (2) and (3)

A B C D

Answer : A (47.9%)
Best distractor: B (31.2%)
Confuse that cones are more important and therefore they are more numerous.

Qn. 4.2

4.2 Tom suffers from an eye defect such that his near point of accommodation is 2 m from his eyes. Spectacle lens of what power is needed to correct his near point to 0.25 m ?

*A. + 3.5 D
B. − 3.5 D
C. + 4.5 D
D. − 4.5 D

A B C D

Answer : A (46.4%)
Best distractors: B, C (21.5%, 21.6%)
Confuse short sight and long sight.
Confuse object / image, real / virtual in lens formula.

Qn. 4.6

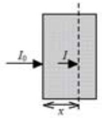
4.6 For scanning the liver which is located inside the body, which of the following choices of ultrasound, with a reason, is correct ?

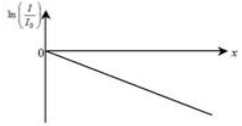
		A	B	C	D
A.	3 MHz ultrasound, as the image is of a higher resolution.	○	○	○	○
*B.	3 MHz ultrasound, as it can travel deeper inside the body.				
C.	12 MHz ultrasound, as the image is of a higher resolution.				
D.	12 MHz ultrasound, as it can travel deeper inside the body.				

Answer : B (45.5%)
Best distractor: D (23.6%)
Poor concept in the effects of frequency on resolution. No idea about the liver size and position.

Qn. 4.7

4.7 An X-ray beam of intensity I_0 is incident on a medium of linear attenuation coefficient μ. After travelling a distance x in that medium as shown, the intensity of the beam becomes I. A graph of $\ln\left(\frac{I}{I_0}\right)$ is plotted against x. What does the **magnitude** of the slope of the graph represent ?





A. $\frac{\mu}{2}$
B. $\frac{\ln 2}{\mu}$
C. $\frac{1}{\mu}$
*D. μ

A B C D
○ ○ ○ ○

$$I = I_0 e^{-\mu x}$$

Answer : D (48.3%)
Best distractor: B (26.3%)
Cannot take log for exponential formula and determine the slope.

Q.4 Structural question

(a) Images *A*, *B* and *C* below were obtained by different medical imaging methods.

A (kidney)

B (body)

C (chest)

(i) Which one is produced by *radionuclide imaging* ? Explain how this image is formed. No need to describe the structure and mechanism of the detecting instrument used. (4 marks)

Q.4 Structural question

4.	(a)	(i)	*B*	1A
			A radioactive / radiopharmaceutical substance is injected to / inhaled by the patient and	1A
			is transported in the blood stream to the rest of the body, the (radioactive) substance accumulates in particular organs.	1A
			Gamma rays emitted by the radioisotope are detected by gamma cameras / The area or location with more (radioactive) substance emits more radiation to the detector and give a darker image.	1A

Most candidates were able to identify the correct picture for radionuclide imaging in (a)(i) and mentioned that the patient needs taking in a radionuclide. However, many failed to point out that the image is formed by the accumulation of radionuclide at the target organ. They simply stated that an image is formed as there is radionuclide and ignored the crucial fact that its contrast is caused by the difference in concentration of radionuclide in the body. Some candidates mixed up the working mechanism with that of X-ray photography and wrongly reasoned by the attenuation through the body.

Q.4 Structural question

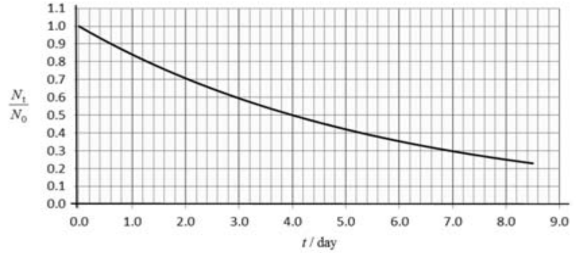
(ii) State **ONE** advantage of radionuclide imaging over the other two imaging methods. (1 mark)

(ii)	Advantage: A hot spot (above normal uptake) or a cold spot (below normal uptake) can infer some problem with the organ, i.e. functional diagnosis.	1A

In answering (a)(ii), many stated the advantages of other methods such as ‘less harmful’ and ‘high resolution’.

Q.4 Structural Question

(b) A radioactive isotope of initial amount N_0 decays to become N_t after time t. The graph below shows the variation of the ratio $\frac{N_t}{N_0}$ with time t.



(i) Use the graph to find the half-life of the radioactive isotope. (1 mark)

A chemical compound containing this radioactive isotope is used as a ‘tracer’ for injecting into a patient to study a physiological process. The biological half-life of this ‘tracer’ is 2 days.

(ii) What is meant by the **biological half-life** of the ‘tracer’ ? (1 mark)

Q.4 Structural question

(b)	(i)	$T_{phy} = 4$ days (or 96 h or 3.46×10^5 s)	1A
	(ii)	Period of time required to reduce the amount of ‘tracer’ in the body / organ to one-half of its original value due to biological process /elimination / excretion / urination /waste removal / metabolism.	1A

Part (b)(i) was well answered.
Although most candidates knew the meaning of half-life, a lot of them failed to point out that the radionuclide is being removed by a *biological process* in (b)(ii).

Q.4 Structural Question

(iii) If 50 mg of this ‘tracer’ is injected initially, estimate the time taken for the amount of this *radioactive* chemical compound *remaining* in the body to drop to 10 mg. (3 marks)

(iii)

$$\frac{1}{T_{eff}} = \frac{1}{T_{phy}} + \frac{1}{T_{bio}} = \frac{1}{2} + \frac{1}{4}$$

$T_{eff} = 1.33$ days — 1M

$N = N_o e^{-kt}$, $k = \frac{\ln 2}{T_{eff}}$ or $\frac{N}{N_o} = (\frac{1}{2})^n$, $t = nT_{eff}$ — 1M

$$t = \frac{-T_{eff}}{\ln 2}\ln(\frac{10}{50}) \text{ or } 10 = 50\,(\frac{1}{2})^{t/T_{eff}}$$

$$t = \frac{-1.33}{\ln 2}\ln(\frac{10}{50}) \text{ or } 10 = 50\,(\frac{1}{2})^{t/1.33}$$

≈ 3.096 days — 1A

In (b)(iii), not many were able to get the correct effective half-life.
Some of them simply used either physical or biological half-life in the calculation even though they knew how to apply the formula of exponential decay.