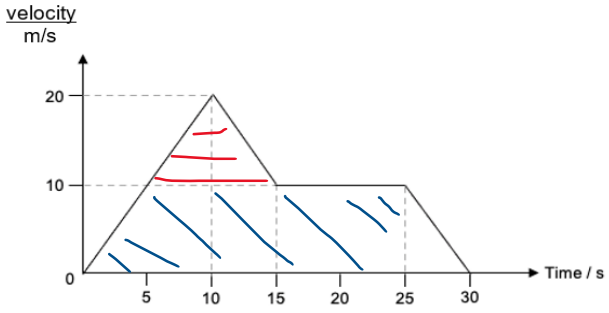
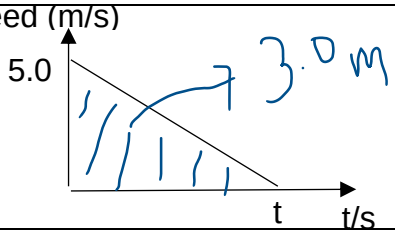
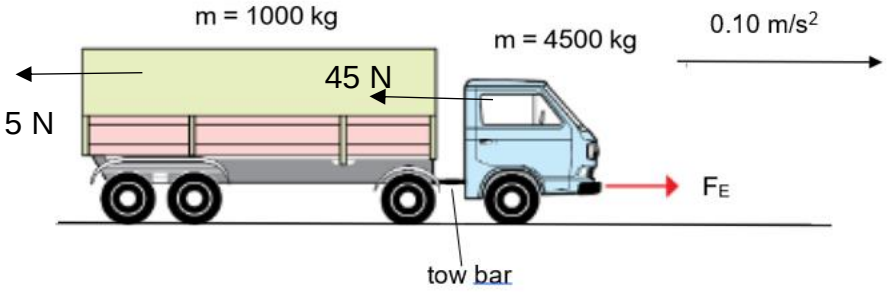
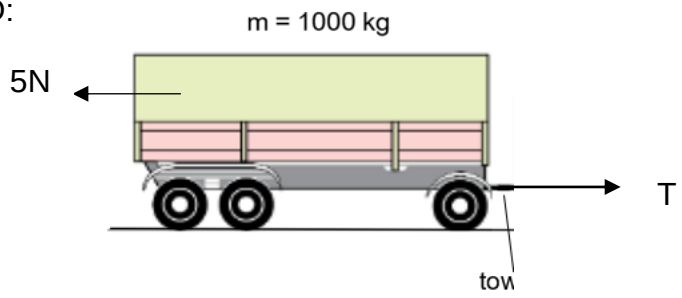
CHR SEC 4 EXP SCIENCE PHYSICS (5086) PRELIM 2024
PROPOSED MARKING SCHEME (FOR TEACHERS ONLY)

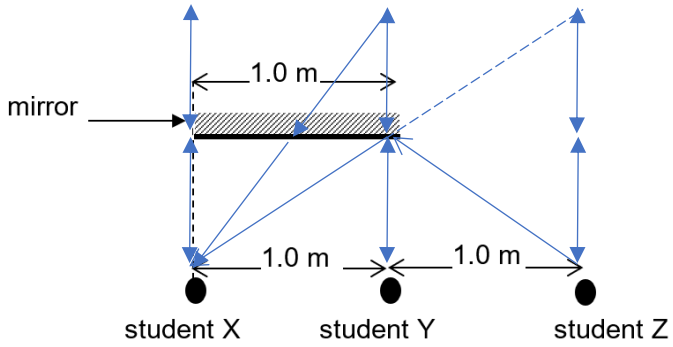
Paper 1:

Q	A	Q	A	Q	A	Q	A	Q	A	Q	A	Q	A	Q	A
1	**A**	6	**C**	11	**D**	16	**C**	21	**B**	26	**C**	31	**B**	36	A
2	**C**	7	**D**	12	**B**	17	**D**	22	**A**	27	**D**	32	**B**	37	B
3	**B**	8	**C**	13	**B**	18	**C**	23	**D**	28	**B**	33	**A**	38	C
4	**B**	9	**B**	14	**A**	19	**D**	24	**C**	29	**B**	34	**D**	39	D
5	**A**	10	**D**	15	**C**	20	**B**	25	**A**	30	**D**	35	**B**	40	C

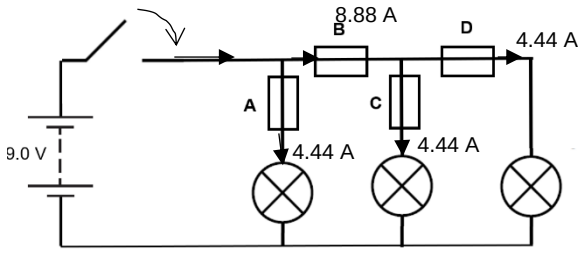
Q	Suggested Answer-Concept-Explanation (ACE approach)	Marks
1	**Answer (A):** A **Concept (C):** Range and precision of instrument **Explanation (E):** Internal diameter of test-tube -digital calipers Thickness of wire – digital micrometer screw gauge	[1]
2	**A:** C **C:** Common examples of scalar and vector quantities **E:** Four vector quantities: i. force, ii. displacement, iii. acceleration, iv. change of velocity	[1]
3	**A:** B Distance travelled = area under speed-time graph [C] = [½ (25 + 20) (10)] + ½ (10) (10) [E] = 275 m [A]  Average speed = total distance travelled / total time taken [C] = 275 / 25 [E] = 11 m/s [A]	[1]
4	**A:** B **C:** Area under speed-time graph =3.0 ½ (5) (t) = 3.0 [E] ∴t = 1.2 s [A] 	[1]

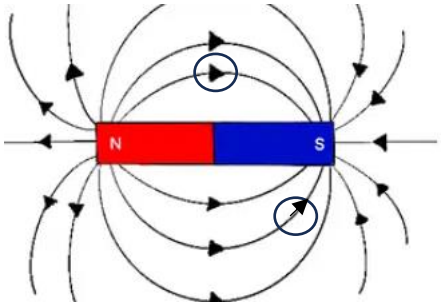
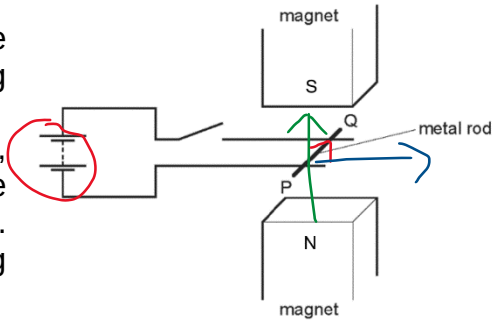
5	**A:** A **C:** Acceleration of free-fall near earth surface, disregard air resistance **E:** Constant acceleration	[1]
6	**A:** C **C:** inertia **E:** mass is the property that resists change in motion of the body	[1]
7	**A:** D **C: Resultant force F = ma** F_E - 45 - 5 = (4500 + 1000) (0.10) [E] F_E = 600 N  FBD:  Resultant force F = ma [C] T -5 = 1000 (0.1) [E] ∴ T = 105 N Use FBD on the engine to check.	[1]
8	**A**: C **Using Principle of Moments, taking moments about P,** Sum of CWM = Sum of ACWM [C] F x 0.75 = W x 0.25 [E] W = 3F ∴ F = 1/3 W Total upward force = Total downward force [C] F + P = W P = W – F = W - 1/3 W = 2/3 W Alternatively, take moments about 100 cm mark to arrive at P = 2/3 W	[1]
9	**A:** B; Object with broadest base, lowest CG [E] gives the greatest stability [C]	[1]

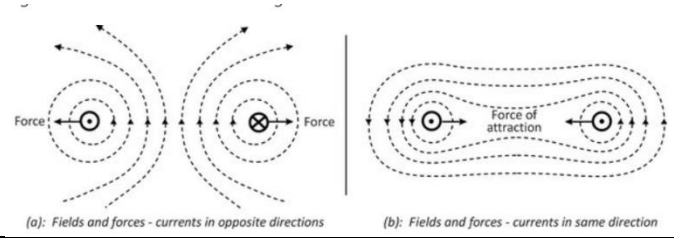
<table>
<tr><td>10</td><td>A: D
Adding weights lower the CG [E] such that the CG is below the pivot for stability. [C]</td><td>[1]</td></tr>
<tr><td>11</td><td>A: D
For hydraulic press system, pressure is transmitted from piston X to piston Y. $P_x = P_Y$; $\frac{F_x}{A_x} = \frac{F_Y}{A_Y}$; $F_Y = F_x \frac{A_y}{A_x}$ [C]
E: reducing diameter of X and increasing the diameter of Y will increase the force to life the load at Y.</td><td>[1]</td></tr>
<tr><td>12</td><td>A: B
As the box moves up the rough slope, there would be some energy is transferred in the form of heat to the surrounding. [E]
C: Principle of conservation of energy.</td><td>[1]</td></tr>
<tr><td>13</td><td>A: B
During boiling, the temperature of the liquid remains constant. [C] Thus the average speed of the particles remain constant and the internal kinetic energy of the particles will also remain constant. [E]. The energy taken in will be used to overcome the intermolecular forces of attraction between the particles. [A] Internal potential energy will increase.</td><td>[1]</td></tr>
<tr><td>14</td><td>A: A
Heat conduction [C] rate: [E]
<table>
<tr><td>aluminium</td><td>L</td><td>12 s to rise by 2°C</td><td>✓</td></tr>
<tr><td>Copper</td><td>L</td><td>6 s to rise by 2°C</td><td></td></tr>
<tr><td>Fibreglass</td><td>L</td><td>77 s to rise by 2°C</td><td>✓</td></tr>
<tr><td>Polystyrene</td><td>L</td><td>30 s to rise by 2°C</td><td></td></tr>
</table></td><td></td></tr>
<tr><td>15</td><td>A: C
E = mcΔT [C]
c = $\frac{E}{m\Delta T}$ [E]</td><td></td></tr>
<tr><td>16</td><td>A: C
C: Electrical energy supplied = Heat gain during boiling
E: $Pt = mL_v$
$1500 \times (700 - 100) = 0.550 \times L_v$
$\therefore L_v = 1600$ kJ/kg</td><td></td></tr>
<tr><td>17</td><td>A: D
• Frequency of the waves remain the same as it is dependent on the dipper (source). [C]
• Speed of waves, v = fλ [C]
= 2.5 x (3.0 cm) [E]
= 7.5 cm/s [A]
• This wave is ta transverse wave [C]
• Wavefronts [C] are farther apart in the deep region and closer together in the shallow region as observed from the wavelengths.</td><td></td></tr>
</table>

<table>
<tr><td>18</td><td>A: C
Wavelength = 2.0 m (from displacement-distance graph) [E]
Amplitude = 0.50 m (from both graphs) [C]
Frequency = 1/T [C] = 1/ 4.0 = 0.25 Hz (from displacement-time graph)
Speed = fλ [C] = (0.25 x 2.0) = 0.50 m/s</td><td>[1]</td></tr>
<tr><td>19</td><td>A: D
High frequency electromagnetic waves such as X-rays and γ-rays can cause ionising effects on living cells. [E] (not heating effects). Infra-red and especially ultraviolet rays result in heating effect; skin cancer. Over-exposure to radio waves does not cause skin cancer.</td><td>[1]</td></tr>
<tr><td>20</td><td>A: B
Only student X can see the images of the other two students as shown.
Student Y can only see image of student X but not student Z.
Student Z can only see image of student X but not student Y.
 

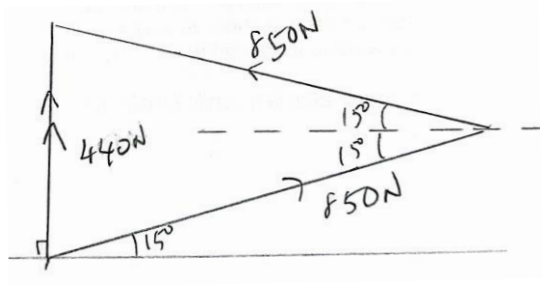
Object distance is same as image distance for plane mirror. [C]</td><td>[1]</td></tr>
<tr><td>21</td><td>A: B
Image is real, inverted and magnified. Magnification is 2.0
When object is placed less than focal length, image is upright and magnified. [C]
When object is placed at twice focal length, image is same size. [C]</td><td>[1]</td></tr>
<tr><td>22</td><td>A: A
Electrical field pattern between a positive and a negative point charges. [C]</td><td>[1]</td></tr>
<tr><td>23</td><td>A: D
A, B and C are examples of potential hazard in electrostatic charging. D is a useful application of electrostatic. [E]</td><td>[1]</td></tr>
<tr><td>24</td><td>A: C
Q = It [C]
35 = I x 1.0 x 10^{-3} [E]
∴ I = 35 000 A or 35 kA [A]</td><td>[1]</td></tr>
<tr><td>25</td><td>A: B; Concept R = ρL/A
<table>
<tr><td>R</td><td>L</td><td>D</td></tr>
<tr><td>4R</td><td>L</td><td>D/2</td></tr>
<tr><td>2R</td><td>L/2</td><td>D/2</td></tr>
<tr><td>R/4</td><td>L</td><td>2D</td></tr>
</table></td><td>[1]</td></tr>
</table>

<table>
<tr><td>26</td><td>A: C
C: Effective resistance in series, parallel and combinations
E:
<table><tr><td rowspan="2">Effective resistance</td><td>P</td><td>Q</td><td>R</td><td>S</td></tr><tr><td>150 Ω</td><td>300 Ω</td><td>33 Ω</td><td>67 Ω</td></tr></table>∴ RSPQ from smallest to highest [A]</td><td>[1]</td></tr>
<tr><td>27</td><td>A: D
C: action of a variable potential divider (potentiometer)
E: A short circuit occurs at 500 Ω resistor. Therefore p.d. across 5.0 kΩ is 5.00 V</td><td>[1]</td></tr>
<tr><td>28</td><td>A: B
C: the effect of temperature increase on the resistance of a metallic conductor and filament lamp
E: As temperature increases, there is increase in vibration of the metallic atoms in their fixed positions. This increases the number of collisions between the free electrons and the metallic atoms, which in turn opposes or slows down the flow of free electrons. Therefore resistance increases and current flow decreases over time.</td><td>[1]</td></tr>
<tr><td>29</td><td>A: B
E:
✓ The annual unit cost of electricity = $542/1650 = $0.328
✓ Total energy consumption per year = 1650 000 x 60 s x 60 min
= 5.94 GJ
✓ When operating for 4.0 min, energy consumed E = VIt [C]
= 2800 x 4.0 x 60s
= 672 kJ
× Operating current I = P/V [C]
= 2800 / 230
= 12. 2 A</td><td>[1]</td></tr>
<tr><td>30</td><td>A: D
C: meaning of the terms live (brown), neutral (blue) and earth (green/yellow) [E]</td><td>[1]</td></tr>
<tr><td>31</td><td>A: B
C: P = IV [C]
40 = I (9.0) [E]
I = 4.44 A
  </td><td>[1]</td></tr>
<tr><td>32</td><td>A: B
C: Soft iron is used for the core of electromagnet and copper wire is used for electromagnet. [E]</td><td>[1]</td></tr>
</table>

33	**A:** A **C:** The plotting compass cane be used to determine the diretion of the magnetic field as shown. [E] 	[1]
34	**A:** D **C:** Properties of magnets **E:** Based on the results recorded, the two possible conclusions can be made.  With these, we can conclude only option D is wrong.	[1]
35	**A:** B When the switch is closed, the metal rod move to the left using Flemimng's left hand rule. [C] To make the rod move to the right, we can reverse the direction of the battery terminals as shown in red. The result will be the rod rolling towards the right. [A] 	
36	**A:** A **C:** Magnetic field lines round straight current-carrying conductors.	[1]

	E: If the directions of the current are in the same direction, there will be attractive force. If they are in opposite direction, there will be repusion as shown below.  (a): Fields and forces - currents in opposite directions (b): Fields and forces - currents in same direction	
37	**A:** B Only when there is a changing magnetic field in the primary coil will induce an e.m.f. [C] and hence a current in the secondary coil. [E]	[1]
38	**A:** C **C:** $\frac{V_S}{V_p} = \frac{N_S}{N_P}$ **E:** $\frac{5.0}{230} = \frac{100}{N_P}$ $\therefore N_p = 4600$	[1]
39	**A:** D Reason why high voltage – low current; less energy wasted in cables [C] Reason why using an alternating current – voltage can be stepped up or down. [E]	[1]
40	**A:** C The diagram illustrates a chain of nuclear fission [C] reactions. Particle X which is a neutron is used to bombard the uranium atom resulting in the decay into two daughter nuclei and more neutrons to further split the uranium atoms. [E]	[1]

PAPER 2: Section A

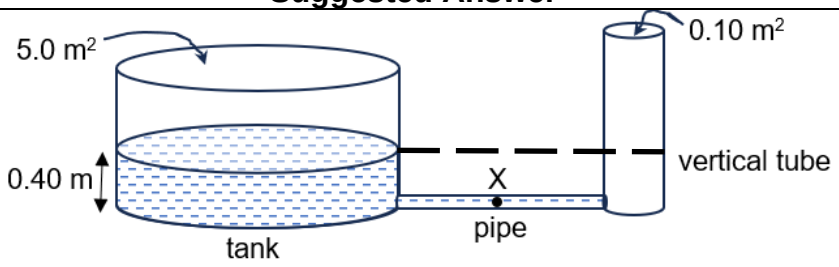
Q	Suggested Answer (ACE approach)	Remarks
1a	*Gravitational field* refers to a region in which a mass experiences a force due to gravitational attraction. [C]	[1]
Comments: Well answered by many students!! 😊		
1b	Scale: 1 cm = 10 N  	[1] [1]

	resultant force = 440 N vertical accept : 420 N to 460 N [A]	[1]
Comments: While scale is given, some students chose very odd scale e.g. 1 cm: 170N which is strongly discouraged. Some students gave the 'seemingly' correct answer with the correct magnitude but wrong orientation. E.g. This is incorrect because:		
1c	Since the CHRian is stationary, the resultant force is zero. Applying Newton's 1st law, the body at rest will remain at rest with resultant force = 0 N. Thus the (weight) downward force is 440 N.	[1] Accept e.c.f. [1]
Comments: The better students are able to quote the correct Newton's Law. Some students are awarded marks for quoting Newton's 2nd Law for sound reasoning. 😊		

Q	Suggested Answer	Remarks
2a	Kinetic store = ½ mv^2 [C] = ½ x (65 000) x $(12)^2$ [E] = **4680 kJ** [A] 3 s.f.	[1] [1]
Comments: Well answered by almost all students except for a small handful who forget to square the value of 12 even though they quoted the formula correctly.		
2b	Efficiency = $\frac{output\ energy}{input\ energy} x100\%$ [C] 72% = electrical energy / 4680 000 kJ [E] Electrical energy = 3 369 600 J in 1s or **3 370 kW** [A] 3 s.f.	Accept e.c.f. [1]
2c	Energy in the kinetic store [C] of wind is transferred mechanically [E] to the kinetic store [C] of the rotor blades of the wind turbine. Energy is transferred **electrically (by charges moving through a potential difference in the presence of the magnets)**	[1] [1]
2d	P=IV [C] 3370 000 = I x (3.5×10^6) [E] I = 0.96 A [A]	[1] Allow e.c.f. [1]
A number of students used E=QV (V=J/C) and Q= It formula which arrive at the same answer of using P=IV directly.		

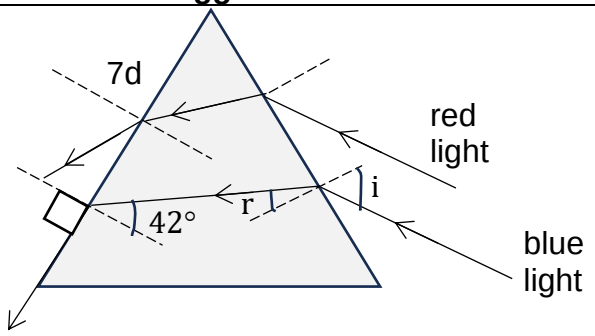
Q	Suggested Answer	Remarks
3a	When more air molecules are pumped in, there will be more air molecules per volume. [E] This will increase the number of	[1]

	collisions per unit time (frequency of collisions increases with the walls of the container) [E] within the same unit area. Thus pressure increases.	[1]
3b	Pressure will increase. [A] When temperature increases, the internal kinetic energy of the air increases. The average kinetic energy (or average speed) of the air molecules increases, leading to greater frequency of collisions between the air molecules and the inner walls of the rocket. [E]	[1] [1]

Q	Suggested Answer	Remarks
4a		[1]
4b	$\rho = \frac{mass}{vol}$ [C] $900 = \frac{mass}{(5.0\ x\ 0.40)}$ [E] ∴mass = 1800 kg [A]	[1] [1]
4c	Pressure = hρg [C] = (0.40) (900) (10) [E] = 3600 Pa Total pressure = 100 000 + 3 600 [E] = 103 600 Pa [A]	[1] [1] [1]

Q	Suggested Answer	Remarks
5a	Energy required to raise the temperature of 1500 kg of water from 25°C to 100 °C = mcθ = (1500) (4200) (100 -25) = 472 500 000 J Energy required to convert 50% steam = mL_v = (1500 /2) x 2260000 = 1695 000 000 J Total energy = 472 500 000 + 1695 000 000 = **2.17×10^9 J**	[1] [1] [1]
5b	Black surfaces are a good absorber of thermal energy through radiation from the ground. Also, metal is a good conductor of heat. So energy can transferred by heating via conduction.	[1] [1]
5c	Speed = distance / time [C] = (250 x 2) / (1.5) [E] = 333 m/s [A]	 [1] [1]

Q	Suggested Answer	Remarks
6a	Longitudinal sound waves produced by the bat cause vibrations [A] of the air molecules, coming together as high pressure regions (compressions) and pulling apart as low-pressure regions (rarefactions), parallel to the direction of wave travel. [C] The sound waves hit the moth and gets reflected back reaching the bat. [E]	[1] [1]
6b	Distance travelled by bat = speed x time [C] = 6.0 x 0.50 [E] = 3.0 m [A] Distance travelled by sound waves = speed x time [C] = 330 x 0.50 [E] = 165 m [A] Total distance = 165 + 3 = 168 ∴ d = 168 /2 [E] = 84 m [A]	[1] [1]
6ci	Any two differences • Radio waves is a transverse wave whereas sound waves is a longitudinal wave. [C] • Sound waves needs a medium to be transmitted whereas radio waves can travel through vacuum at a speed of 3.0 x 10^8 m/s [C] *Accept plausible answers	[1] [1]
6cii	$v = f\lambda$ [C] $3.0 \times 10^8 = 1.5 \times 10^9 \times \lambda$ [E] $\therefore \lambda = 0.20$ m [A]	[1] [1]

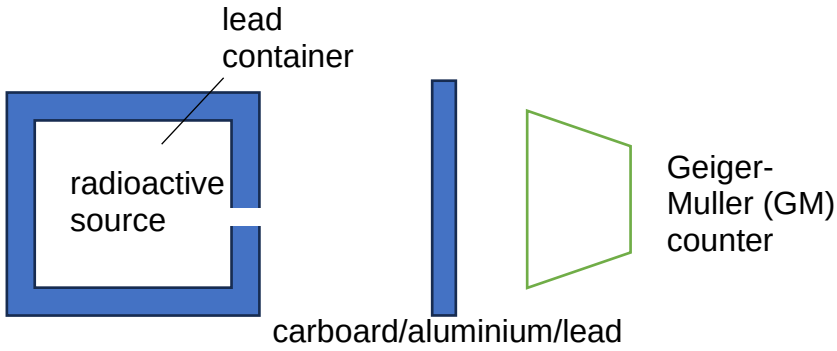
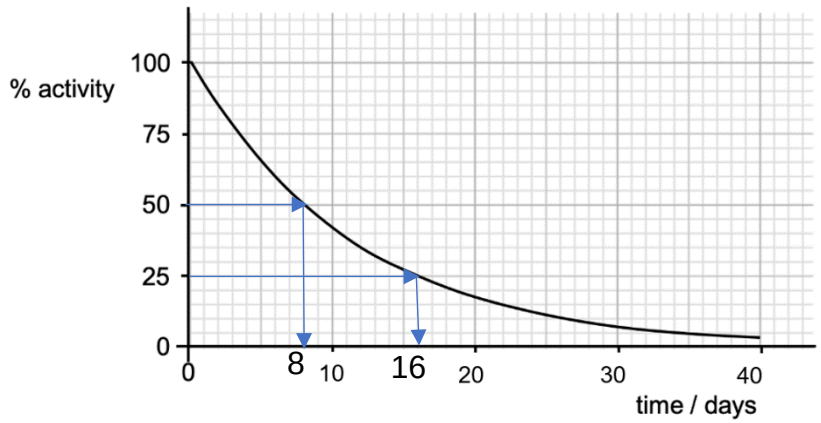
Q	Suggested Answer	Remarks
7a		[1]
7b	Critical angle of 42° is the angle of incident in the optically denser medium for which the angle of refraction in the less dense medium is 90°. Mark on diagram to support the answer.	[1] [1]
7c	$n = \frac{1}{\sin c}$ [C] $n = \frac{1}{\sin 42°}$ [E] $n = 1.49$ [A]	[1]

		[1]
7d	Refer to diagram. Bend towards normal as red light enters glass and Refract away from as red light leaves glass	 [1] [1]

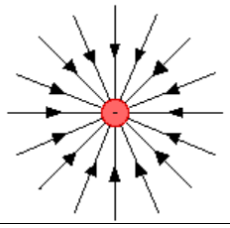
Q	Suggested Answer	Remarks
8a	Effective resistance = $(\frac{1}{R_1}+\frac{1}{R_2})^{-1}$ [C] = $(\frac{1}{(120+120)}+\frac{1}{(200+200)})^{-1}$ [E] = 150 Ω [A]	[1] [1]
8b	Using the concept of potential divider, for V_{out} across the LDR ≥ 6.0 V, [C] $V_{LDR} = \frac{200}{50+200} \times 9.0\ V$ [E] = 7.2 V $V_{LDR} = \frac{100}{50+100} \times 6.0\ V$ [E] = 6.0 V From the working, it shows that the fan will be switched on when the temperature reaches 35 °C, regardless of the light intensity. [A]	[1] [1]]

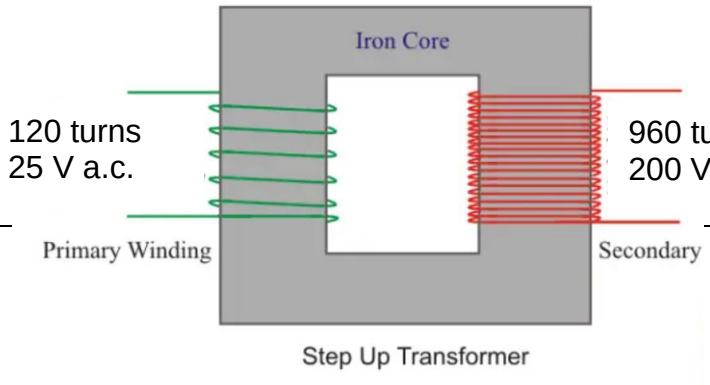
Q	Suggested Answer	Remarks
9a	Carbon brushes [A] Split ring commutator [A]	[1] [1]
9b	Switching the positions of the North and South poles will result in the motor rotating in the opposite direction [E] and increasing the number of turns will cause the motor to rotate faster or at a higher frequency. [E]	 [1] [1]
9c	The toy car starts with zero initial speed, increases its speed at a decreasing rate till it reaches a maximum speed of 12 m/s in 10 s. [E] It speed suddenly decreases at a decreasing rate till it reaches 5.0 m/s in another 10 s. Its speed picks up again till it reaches 12 m/s. The cycle repeats itself every 20 s. [E]	 [1] [1]

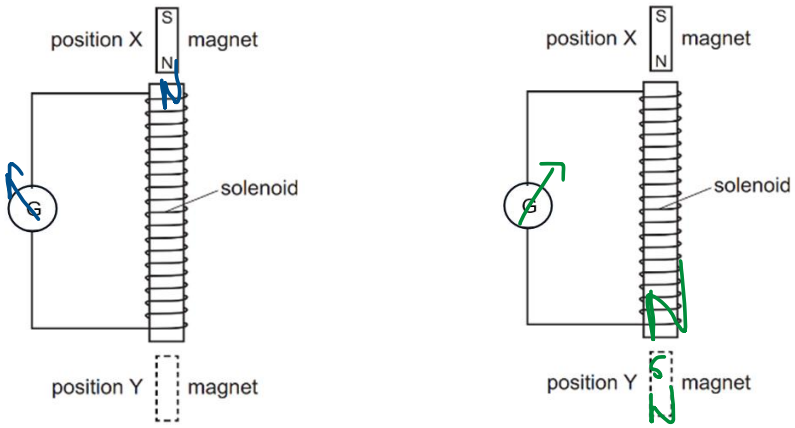
Q	Suggested Answer	Remarks
10a	$^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}\alpha + \gamma$ [A]	[1]
10b	• Use the Geiger-Muller (GM) counter [C]. Check the background radiation. Take note of the count rate, M_1 Expose it to the radioactive element. The count rate should increase. Place a carboard from the radioactive element, the count rate will drop, M_2. This shows that α	

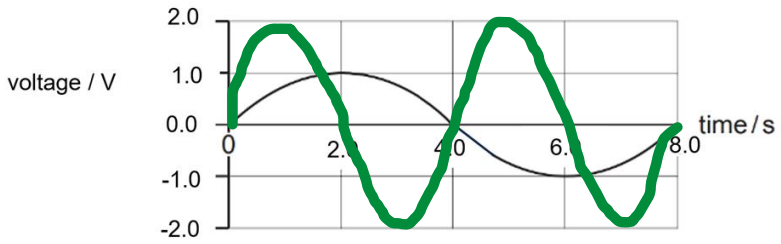
	is present. [E]	[1]
	• Place a few mm of aluminum, it remains at M_2. This shows that β is absent. Next, place a few cm thick of lead, the reading will drop to M_1. This shows that γ-radiation is present. [E]	[1]
	Diagram [A]  	[1]
10ci	Approximately 25 counts per minute [A]	[1]
10cii	604- 25 = 579 (allow e.c.f.)	[1]
10Ciii	Maximum distance = 4.0 cm since the count rate significantly dropped to approximately 25 counts per minute after it goes beyond 5.0 cm. [E]	[1]
10di	Isotopes are atoms of the same element that have the same number of protons but different numbers of neutrons. [C]	[1]
10dii	${}^{234}_{90}Th \rightarrow {}^{234}_{91}Pa + {}^{0}_{-1}\beta + \gamma$ Atomic number of Pa is 91	[1]
10diii	 As shown, half-life of Th isotope is approximately 8 days.	[1] [1]
10e	Any one of these Radioactivity used in medical field • the detection of tumours using γ-rays • treatment of thyroid disorder • in gamma knife to destroy brain tumours	[1]

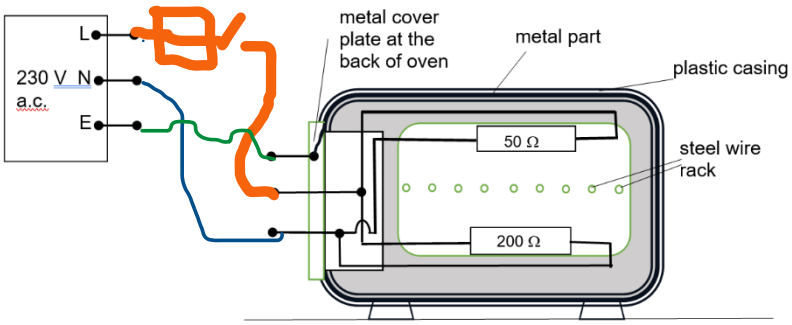
	Radioactivity used in industrial field • β-particles or γ-rays are used to measure the thickness of materials e.g. uniform thickness • α-particles used in smoke detectors	

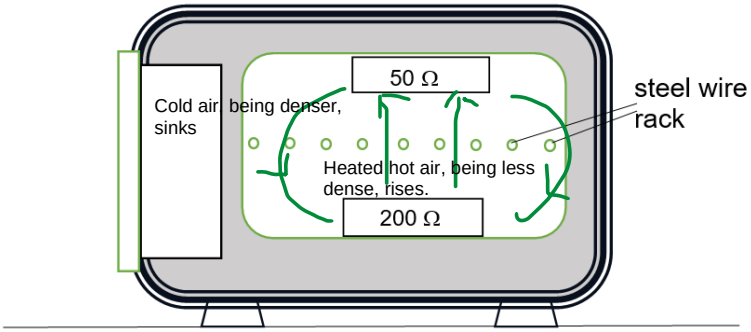
Q	Suggested Answer	Remarks
11a	When the waste gases (initially uncharged) enters the electrostatic precipitator, they rub against the negatively charged rods, they become negatively charged as they gain electrons. [E] Charging by friction [C] As they continue to move pass the positively charged metal plates [E], they get attracted since unlike charges attracted. [C]. Unwanted particles are removed, leaving the clean gas exiting from the precipitator.	[1] [1]
11b		[1]
c	Q = It [C] = 1.5 x 10^{-3} x 2.0s [E] = 3.0 x 10^{-3} C [A] E = QV or V = J/C [C] E = 3.0 x 10^{-3} x 120 x 10^{3} [E] = 360 J [A] Alternatively, E = VIt [C] = (120 x 10^{3}) x (1.5 x 10^{-3}) x (2.0) [E] = 360 J [A]	[1] [1]

Q	Suggested Answer	Remarks
12a	Diagram to show the step-up transformer. [A]  Step Up Transformer	[1]

	25 a.c. supply; laminated soft-iron core [E] $\frac{N_s}{N_p} = \frac{V_s}{V_p}$, [C] $\frac{N_s}{120} = \frac{200}{25}$ [E] $N_s = 960$ [A] • Assumption: no energy losses in the system which means all the energy that is applied to the primary coil are transferred to the secondary coil. [A]	[1] [1] [1]
11b	When the magnet is dropped from the top, the magnetic field will be cut by the conducting wires in the solenoid. [E] An e.m.f. is induced according to Faraday's law of electromagnetic induction [C] and hence a current will be produced. Thus, a current deflection to the is registered to the left. [A]	[1] [1]
11c	When the magnet drop from the middle of the solenoid to the position Y, a deflection of current to the right is registered. [A]  As shown in the diagram, the lower end of the solenoid will be induced N [E] according to Lenz's law [C] and a deflection to the right will be registered.	[1] [1]

11d	 Double the frequency Double the amplitude of the e.m.f.	 [1] [1]

Q	Suggested Answer	Remarks
12a	 Correct identification of the wires Placement of fuse and switch on the live wire	 [1] [1]
13b	$\frac{1}{R_{eff}} = \frac{1}{R_1} + \frac{1}{R_2}$ $\frac{1}{R_{eff}} = \frac{1}{50} + \frac{1}{200}$ $R_{eff} = 40\ \Omega$ V=RI 230 = 40 I ∴I = 5.8 A	 [1] [1]
13c	7A , slightly higher than the operating current of 5.8 A.	[1]
13d	Total energy consumption for 5 operating ovens for a month	

	= (230 x 5.8 /1000) kW x 3 hours x 5 ovens x 30 days = 600.3 kWh Based on energy retailer X: Cost = 600.3 kWh x \$0.30 = \$180.09 Based on energy retailer Y: Cost = 600.3 kWh x \$0.32 = \$192.096 With rebate = \$192.096 - \$15 = \$177.096 Thus retailer Y would provide lesser cost.	[1] [1]
13e	 When the oven is heated, hot air from the base will expand and rise being less dense. [E] Cooler air will sink and in turn get heated up. This process repeats and set up the convection currents. [C] to eventually heat up the food placed on the steel wire rack. [A]	[1] [1]