EXP	PUNGGOL SECONDARY SCHOOL SECONDARY 4 EXPRESS 2024 PRELIMINARY EXAMINATION **QUESTION BOOKLET**

NAME

CLASS

INDEX NUMBER

Physics **6091/02**

Paper 2

22 August 2024

1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your class, register number and name on all the work you hand in.
You may use a soft pencil for any diagrams, graphs, tables or rough working.
Write in dark blue or black pen.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Section A
Answer all questions.
Write your answers in the spaces provided on the question paper.

Section B
Answer **one** question.
Write your answers in the spaces provided on the question paper.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's use	
Section A	/70
Section B	/10
Total	/80

Parent's Signature

This paper consists of **22** printed pages and **0** blank page.

Section A

Answer **all** the questions in the spaces provided.

1 Fig. 2.1 shows how the velocity of a vehicle changes with time.

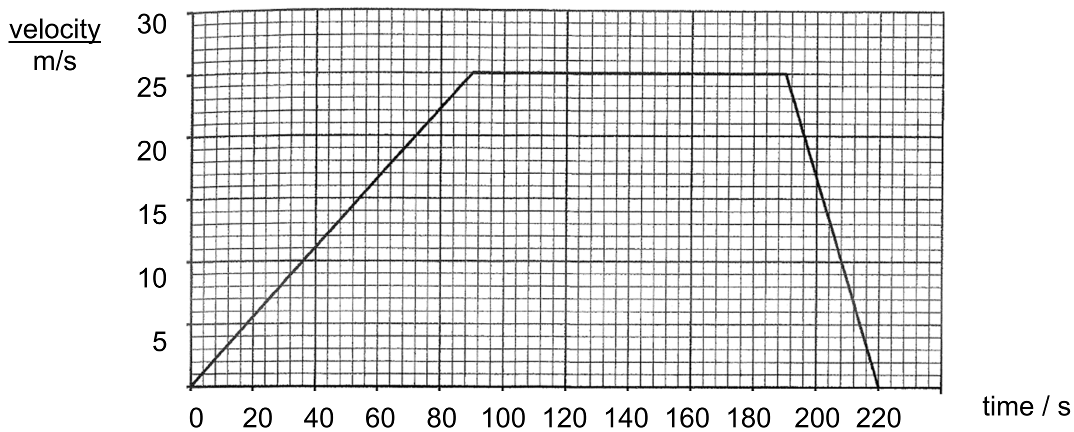

Fig. 1.1

(a) Describe how the displacement of the vehicle changes from t = 0 s to t = 80 s.

……………………………..…………………………………………………...

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……………………………………………………………………………… [2]

(b) Calculate the average velocity for the whole journey.

average velocity = ………………..… [3]

(c) Calculate the deceleration of the vehicle at t = 204 s.

deceleration = ……………………… [2]

[total: 7]

2 Fig. 2.1 shows an aircraft dropping a crate of supplies to a region that is difficult to reach by land vehicles.

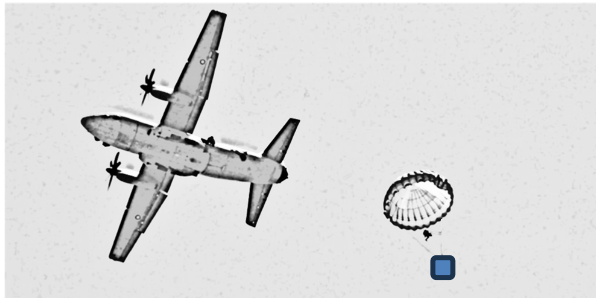

Fig. 2.1

At a certain instant in the crate's descent, it experiences a total resistive force of 1200 N. The total weight of the crate and its contents, including the parachute, is 2500 N.

(a) Draw and label the forces acting on the crate shown in Fig. 2.1 at this instant. [1]

(b) Calculate the total mass of the crate and its contents.

The gravitational field strength is 10 N / kg.

mass = ………………….. [1]

(c) Calculate the acceleration of the crate at the instant shown in Fig. 2.1.

acceleration = ……………………… [3]

(d) Suggest one factor that could affect the air resistance acting on the crate.

……………………………………………………………………….. [1]

(e) As the crate continues descending, it eventually attains terminal velocity.

Explain why the crate attains terminal velocity in terms of forces.

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………………………………………………………………………………...

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…………………………………………………………………………………

……………………………………………………………………….. [2]

[total: 8]

3 A heater is placed at the bottom of a liquid. The liquid is heated until it becomes a gas. Fig. 3.1 shows the variation with time of the temperature of the substance.

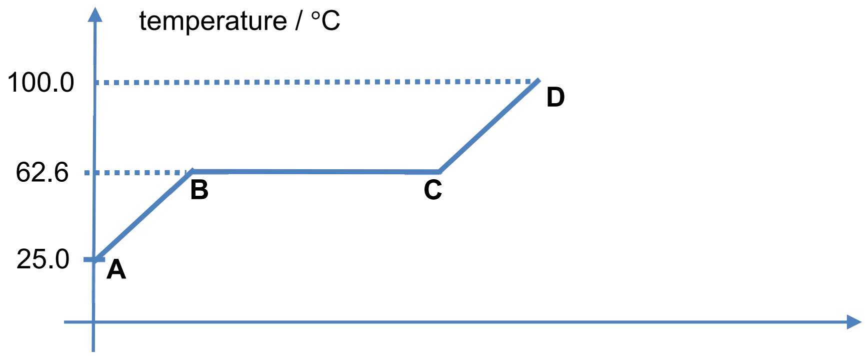

Fig. 3.1

The heater used to heat up the substance transfers energy to the substance at a steady rate.

(a) Describe how the heat is transferred efficiently throughout the liquid.

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....

....

....

.... [2]

(b) Explain, in terms of energy stores, why the temperature of the substance rises from **A** to **B** while the temperature remains constant from **B** to **C,** when the heater is operating normally.

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....

....

....

.... [2]

(c) The experiment is repeated using twice the volume of the liquid while keeping all other variables constant.

Sketch on Fig. 3.1 to show the new variation of temperature with time. [1]

(d) Describe the changes to the arrangement of the particles from **B** to **C** using the kinetic particle model of matter.

…………………………………………………………………………………...

…………………………………………………………………………………...

………………………………………………………………………………….. [1]

[total: 6]

4 Smoke particles are observed under a microscope. The particles are observed to move about randomly.

(a) Explain why the smoke particles appear to move about randomly.

…………………………………………………………………………………...

…………………………………………………………………………………...

…………………………………………………………………………………...

………………………………………………………………………………….. [2]

(b) The lamp of the microscope heats up the sample of smoke particles being observed.

(i) Predict how the motion of the smoke particles would be different.

……………………………………………………………………………….

……………………………………………………………………………… [1]

(ii) Explain your answer to **(b)(i)**.

……………………………………………………………………………….

……………………………………………………………………………… [1]

[total: 4]

5 Fig. 5.1 shows a manometer used to measure the pressure of a gas in a syringe that is connected to one end of the manometer. The manometer is filled with mercury which has a density of 13 600 kg / m^3.

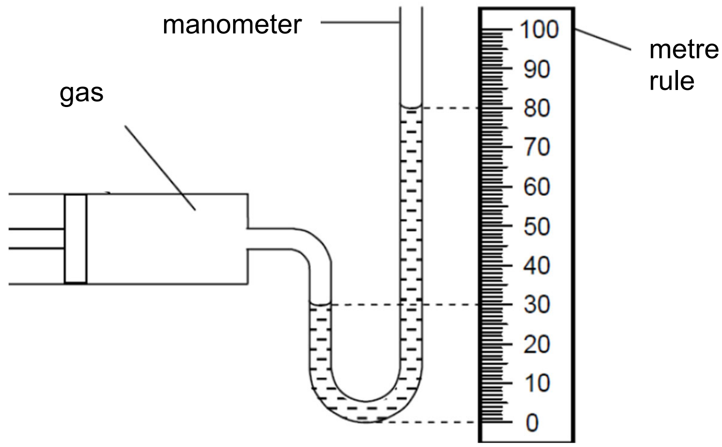

Fig. 5.1

(a) Explain how the gas particles in the syringe are able to exert such a high pressure to lift the column of mercury in the manometer on the right arm.

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

…………………………………………………………………………….. [2]

(b) The atmospheric pressure is 760 mm Hg.

Calculate the gas pressure. Leave your answer in mm Hg.

gas pressure = ………………………mm Hg [1]

(c) Fig. 5.2 shows the piston pushed further to the right by a force F and the mercury level on the right arm of the manometer is observed to rise.

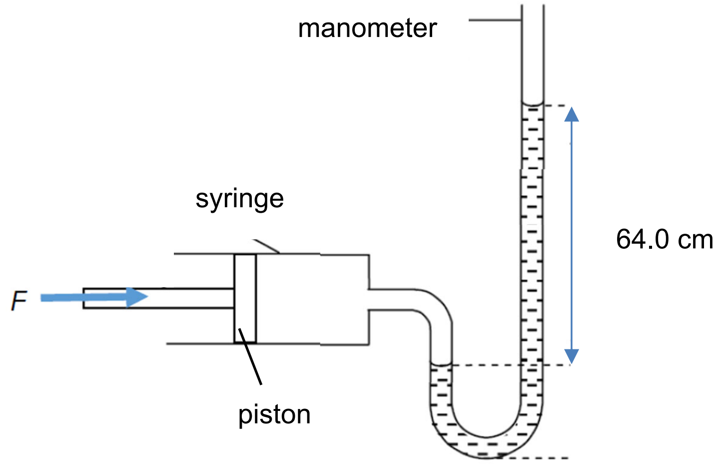

Fig. 5.2

(i) Explain why the mercury level on the right arm rises when the piston is pushed to the right using the ideas of particles.

……………………………………………………………………………

……………………………………………………………………………

…………………………………………………………………… [1]

(ii) Calculate the increase in gas pressure with reference to Fig. 5.1 and Fig 5.2. Leave your answer in Pa.

The gravitational field strength is 10 N / kg.

gas pressure = ……………………… Pa [2]

(iii) The cross-sectional area of the piston is 12 cm^2. Calculate the magnitude of the force F, assuming that no energy was transferred out of the system.

force = ……………………… [2]

[total: 8]

6 Visible light is a component of the electromagnetic (EM) spectrum, which consists of waves of different wavelengths. All EM waves can undergo reflection and refraction.

(a) State one other property that is common for all components of the electromagnetic spectrum.

………………………………………………………………………………...

…………………………………………………………………………….. [1]

(b) Fig. 6.1 shows a ray of blue light entering a glass block from air. The refractive index of the glass block is 1.52. The ray bends to hit surface **PQ**.

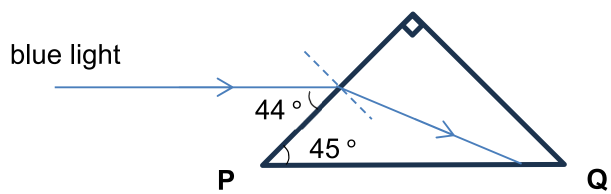

Fig. 6.1

(i) Calculate the angle of refraction for this ray.

angle of refraction = ………………. ° [2]

(ii) Calculate the critical angle for the glass block.

critical angle = ………………. ° [1]

(iii) Calculate the angle of incidence at the surface **PQ**.

angle of incidence = ………………. ° [1]

(iv) Hence, draw a ray in Fig. 6.1 to show the path of the light ray after it is incident on the surface **PQ**. [1]

[total: 6]

7 Fig. 7.1 shows a simplified model of an electrostatic precipitator.

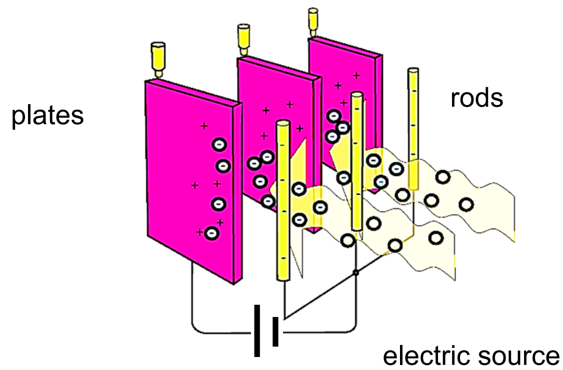

Fig. 7.1

Exhaust fumes containing dust particles are passed through metallic rods and plates that are connected to an electric source.

Dust particles passing through the rod acquire negative charges.

(a) Fig. 7.2 shows an isolated negative charge.

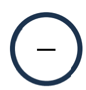

Fig. 7.2

(i) Draw the electric field pattern due to the charge on Fig. 7.2. [1]

(ii) State what is shown by the direction of the electric field.

....

.... [1]

(b) Explain how the electrostatic precipitator helps to produce cleaner air.

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

…………………………………………………………………………….. [2]

[total: 4]

8 A student sets up a circuit as shown in Fig. 8.1 to investigate the brightness of a lamp of resistance 5.0 Ω. A heater is placed very near a thermistor so that the temperature of the thermistor varies.

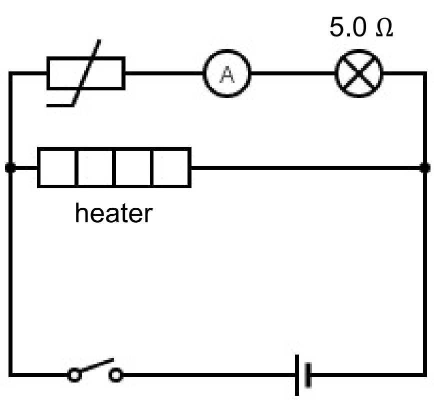

Fig. 8.1

(a) On Fig. 8.1, draw a suitable instrument to show how the potential difference across the thermistor can be measured. [1]

(b) When the switch is first closed, the lamp fails to light up.

(i) Suggest why the lamp fails to light up at first.

………………………………………………………………………………

…………………………………………………………………………… [1]

(ii) Explain why the lamp lights up after some time.

………………………………………………………………………………

…………………………………………………………………………… [1]

(c) The current and potential difference across the thermistor obtained from the experiment is shown in Fig. 8.2.

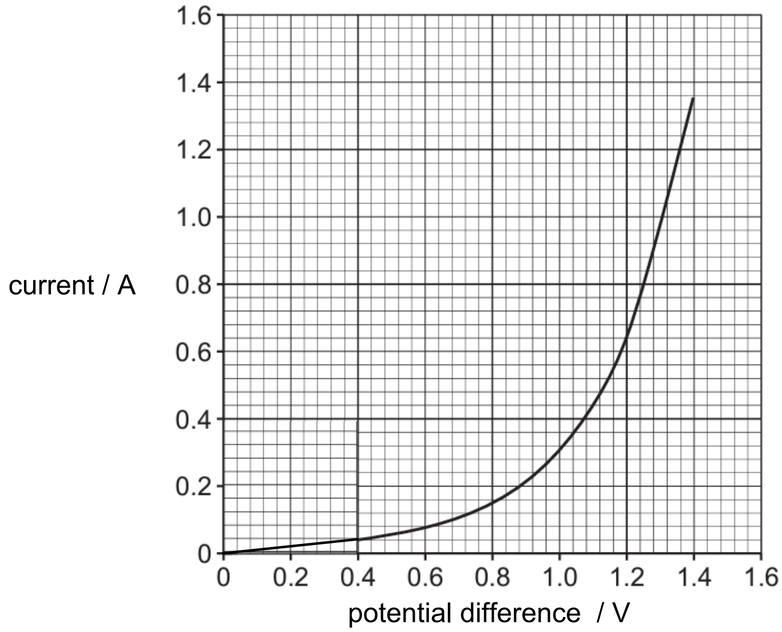

Fig. 8.2

(i) The current through the lamp is 0.48 A at one point in the experiment.

Find the e.m.f of the cell.

e.m.f = ...

[3]

(ii) The student discusses the graph in Fig. 8.2 with another student, and they conclude that the thermistor exhibits ohmic properties under certain conditions.

Suggest why they came to this conclusion.

....

....

.... [1]

[total: 7]

9 Fig. 9.1 shows an instrument that can be used to detect earthquakes. A bar magnet is suspended from a spring hanging from a metal rod. The metal rod is firmly attached to the base of the instrument and transmits vibrations on the ground to the magnet, causing it to oscillate. The coil is connected to a monitor which measures and displays the induced e.m.f in the coil.

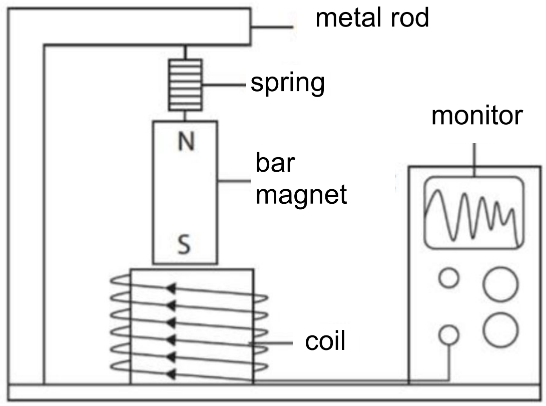

Fig. 9.1

(a) In a test, a student lowers the bar magnet into the coil and then withdraws the bar magnet. The monitor registers a reading momentarily, indicating that an e.m.f is induced.

(i) Explain why an e.m.f is induced in the circuit.

………………………………………………………………………………

……………………………………………………………………… [1]

(ii) The direction of the current induced at one moment in this test is shown in Fig. 9.1.

Deduce whether the bar magnet was moving in or out of the coil at the moment shown in Fig. 9.1

……………………………………………………………………… [1]

(iii) Explain your answer to **(a)(ii)**.

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………………………………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

……………………………………………………………………… [2]

(b) During an earthquake, the monitor registers 50 vibrations in a second and a maximum e.m.f of 500 mV.

On Fig. 9.2, sketch the voltage-time graph showing the induced e.m.f registered by the monitor.

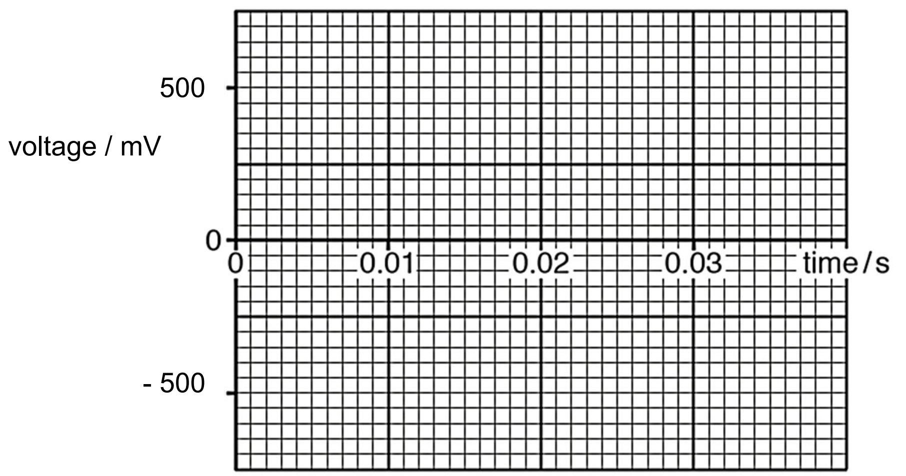

Fig. 9.2

[2]

(c) Describe two differences in your sketch in Fig. 9.2 if an earthquake that creates 25 vibrations in one second is registered by the instrument shown in Fig. 9.1.

…………………………………………………………………………………...

………………………………………………………………………………….. [1]

(d) In another test, it was found that the monitor registered no reading when the tremors are small. Suggest how the instrument could be modified so that the induced e.m.f is larger.

…………………………………………………………………………………...

…………………………………………………………………………………...

………………………………………………………………………………….. [1]

(e) The coil is removed from the set up in Fig. 9.1, and connected to a battery, as shown in Fig. 9.3. An iron core is inserted into the coil, and an iron pendulum bob is suspended near the coil.

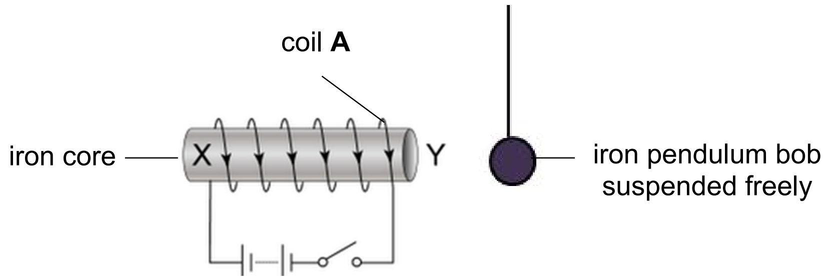

Fig. 9.3

The switch is closed and the iron pendulum bob is observed to swing towards **Y**, one end of the iron core.

Explain why the pendulum bob swings towards Y when the switch is closed.

…………………………………………………………………………………...

…………………………………………………………………………………...

…………………………………………………………………………………...

…………………………………………………………………………………...

……………………………………………………………………………….. [3]

[total: 11]

10 Bubble tea is a popular beverage made by mixing flavoured syrup to tea. Chewy starch balls, called “pearls”, are often added to the beverage.

Fig. 10.1 shows a typical drink where fixed volumes of syrup, tea, ice, and pearls are mixed together.

Fig. 10.1

Table 10.2 shows the amount of each ingredient used for drinks of different sizes, the values of their specific heat capacities and specific latent heat of fusion, and the temperature of each ingredient before they are first mixed.

Table 10.2

	tea		syrup		pearls		ice	
size	small	large	small	large	small	large	small	large
mass added / g	300	450	35	50	120	150	300	450
specific heat capacity J / (g K)	4.5		3.1		3.5		2.1	
specific latent heat of fusion J / g	340		390		-		330	
temperature before they are first mixed °C	65		26		36		0	

(a) Explain what is meant by a *specific heat capacity of 4.5 J / (g K)*.

…………………………………………………………………………………..

…………………………………………………………………………………..

……………………………………………………………………………… [1]

(b) A drink is usually served at 4 °C

(i) Suggest why more ice is added when a large drink is prepared.

……………………………………………………………………………….

……………………………………………………………………………… [1]

(ii) Using information from Table 10.2, calculate the amount of energy transferred out of the internal store of the syrup for its temperature to decrease to 4 °C for a small-sized beverage.

amount of energy = …………………… [2]

(iii) Using information from Table 10.2, calculate the total amount of energy transferred out of the internal stores of the ingredients for a small-sized beverage to be 4 °C.

total amount of energy = …………………… [1]

(iv) State the amount of energy transferred to the internal store of the ice when it attains thermal equilibrium with the beverage at 4 °C.

amount of energy = …………………… [1]

(v) Hence, calculate the minimum mass of ice required to obtain a small beverage at 4 °C using information from Table 10.2.

The specific heat capacity of water is 4.2 J / (g K).

minimum mass = …………………… [3]

[total: 9]

Section B

Answer **one** question from this section.

11 Isotopes of some elements may be unstable and undergo nuclear decay, releasing radiation. One example is the isotope radium-226, which decays into radon-222 with the emission of an alpha particle.

(a) In nuclide notation, radium-226 is written as $^{226}_{88}\mathrm{Ra}$. Write the equation to represent the alpha decay of radium-226 to radon-222. The chemical symbol for radon is Rn.

[2]

(b) Radioactive substances are used in some medical procedures, and they should be handled with care as they can be dangerous to living organisms.

(i) Explain why exposure to alpha particles could be more harmful than exposure to gamma radiation.

…………………………………………………………………………

…………………………………………………………………………

……………………………………………………………………….. [1]

(ii) Suggest how medical professionals who handle the radioactive isotope radium-226 frequently may protect themselves from the harmful effects of radioactivity.

…………………………………………………………………………

…………………………………………………………………………

……………………………………………………………………….. [1]

(c) The isotope radon-222 is also unstable and continues to decay into smaller nuclides. The half-life of radon-222 is 8.3 days.

The initial mass of a sample of radon-222 before decay is observed to be 100 g. Calculate the number of days it will take for 12.5 g of radon-222 to be left in the sample.

number of days = …………………….. [2]

(d) A student measures the count rate of a sample of radon-222 to determine its half-life.

Describe how he could determine an accurate count rate for the sample of radon-222 using a named apparatus.

………………………………………………………………………………..

………………………………………………………………………………..

………………………………………………………………………………..

……………………………………………………………………………… [2]

(e) A beam of the alpha particles is directed into a uniform magnetic field as shown in Fig. 11.1.

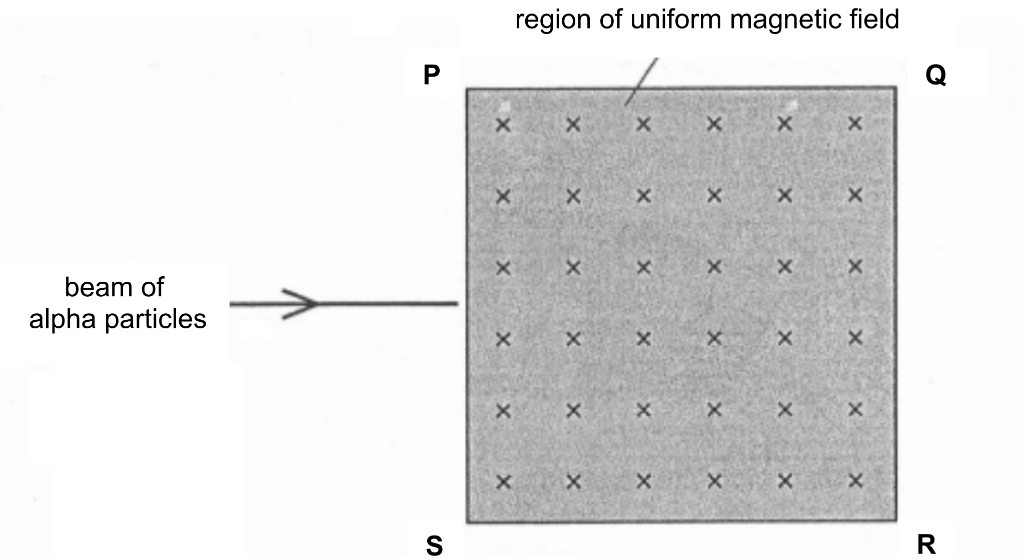

Fig. 11.1

(i) Draw the subsequent path of the alpha particles as they pass into the magnetic field in Fig. 11.1. [1]

(ii) The beam of alpha particles is replaced with a beam of gamma radiation.

Explain how your answer to **(e)(i)** will be different.

………………………………………………………………………………

………………………………………………………………………………

……………………………………………………………………… [1]

[total: 10]

12 A crane uses a motor to lift a concrete slab of weight 2400 N as shown in Fig. 12.1.

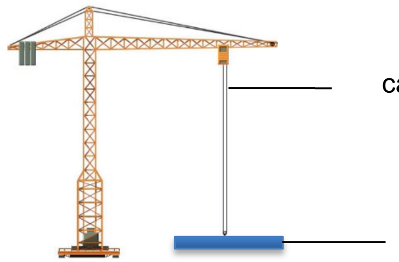

Fig. 12.1

(a) State the *principle of conservation of energy*.

…………………………………………………………………………………...

…………………………………………………………………………………...

……………………………………………………………………………….. [2]

(b) The concrete slab was lifted from the ground to a height of 25 m in 1.2 minutes at constant speed.

(i) Calculate the useful power output of the motor.

useful power output = …………………… [2]

(ii) The efficiency of the motor is 65%. Calculate the minimum power input required by the motor.

minimum power input = …………………… [1]

(iii) In a safety simulation, engineers conducted an experiment to find out the damage that faulty cables could cause to the construction site, in the event that the cables snap and the concrete slab falls.

The concrete slab is released 25 m above the ground. Calculate the maximum speed of the slab just before reaching the ground.

speed = …………………… [2]

(c) Fig. 12.2 shows a counterweight of 12 000 N used to balance the crane, which is pivoted at **X**. The weight of the frame of this crane is 150 000 N, and its centre of gravity is at the point **G**, 0.20 m away **X**.

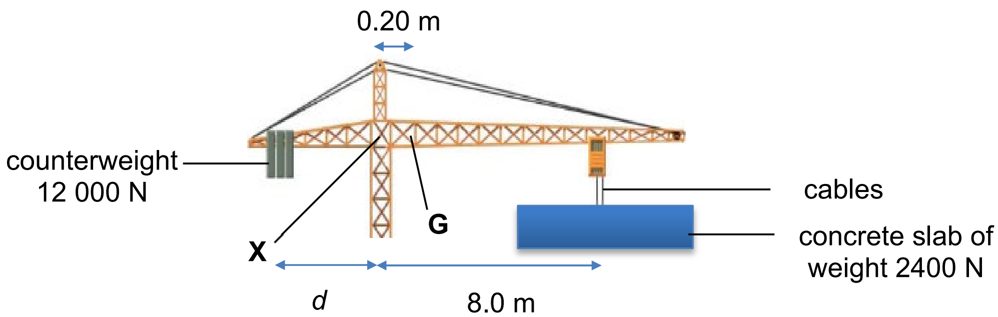

Fig. 12.2

Given that the crane is in equilibrium when the concrete slab is 8.0 m away from the pivot **X**, calculate *d*, the distance the counterweight is from **X**.

d = …………………… [3]

[total: 10]

– End of paper –