Cambridge O Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

PHYSICS **5054/21**

Paper 2 Theory **May/June 2022**

1 hour 45 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Section A: answer **all** questions.
- Section B: answer **two** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 75.
- The number of marks for each question or part question is shown in brackets [ ].

Section A

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

1 Fig. 1.1 shows a model of the human arm. The rubber band represents the muscle that moves part of the arm XY up.

A mass is suspended from XY, as shown in Fig. 1.2. The weight of section XY is negligible and the model is at rest.

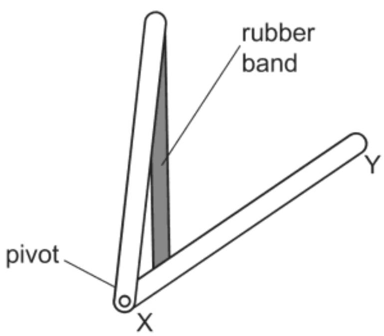


Fig. 1.1

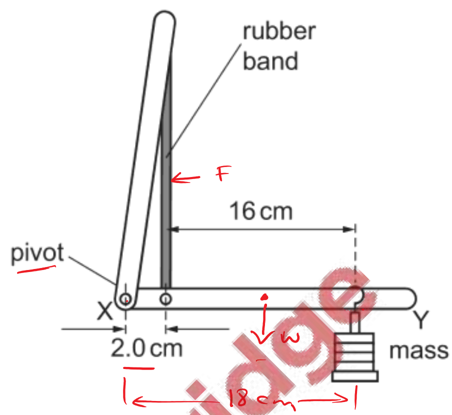


Fig. 1.2 (not to scale)

(a) **(i)** State **two** ways in which the dimensions of the rubber band change as the mass is added to section XY.

- Rubber becomes longer
- Rubber becomes thinner [2]

(ii) State the form of energy stored in the stretched rubber band.

Elastic potential energy [1]

(b) **(i)** State the principle of moments.

– When object is in equilibrium the sum of clockwise moment is equal to the sum of anticlockwise moments. [2]

(ii) Explain why the force that the rubber band exerts on section XY is larger than the weight of the mass.

– the distance of rubber band to pivot is smaller than distance of mass from pivot.

.... [1]

(iii) The mass suspended from section XY in Fig. 1.2 has a weight of 4.0 N.

Calculate the force that the rubber band exerts on section XY.

M = F×d

F × 2 = 4 × 18

F = 4 × 18 / 2

= 36 N

force = 36 N [2]

(iv) Explain how your answer to **(b)(iii)** is different if the weight of section XY is **not** negligible.

– The force on the rubber band should be greater in order to contribute more anticlockwise moment to counter the now more clockwise moments. [1]

[Total: 9]

2 Fig. 2.1 shows a wind turbine.

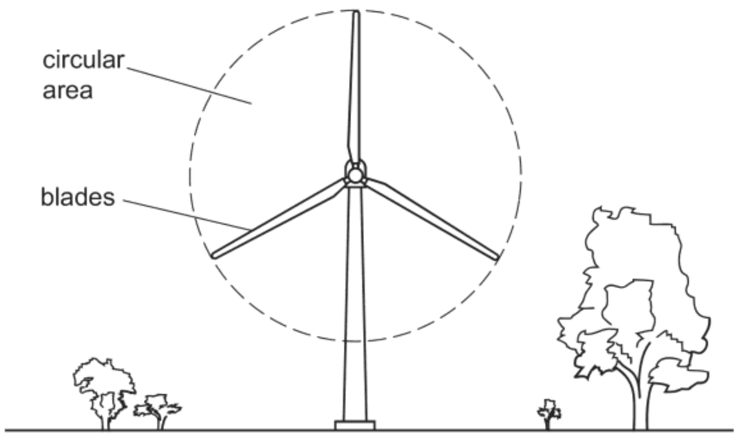


Fig. 2.1

(a) The wind blows directly towards the turbine with a speed of 12 m/s.

In one second, 60 000 kg of air passes through the circular area swept out by the blades.

Calculate the kinetic energy of this mass of air.

$K \cdot E = \frac{1}{2} \times m \times v^2$

$= \frac{1}{2} \times 60000 \times 12^2$

$= 4,320,000\ J$

$= 4300,000\ J$

$= 4.3 \times 10^6\ J$

kinetic energy = $4.3 \times 10\ J$ [3]

(b) A wind turbine releases no carbon dioxide into the atmosphere while generating electricity. Compared with a coal-fired power station, this is an advantage of using a wind turbine.

(i) State **one** reason why it is important to reduce the amount of carbon dioxide produced.

this reduces global warming caused by CO_2. [1]

(ii) Suggest **one** advantage of using a coal-fired power station compared with a wind turbine.

- coal-fired power station is more reliable, since wind is not alway blowing. [1]

- wind harms birds

(c) A coal-fired power station releases 0.96 kg of carbon dioxide when it generates 1.0 kWh of electrical energy.

(i) Define the kilowatt-hour (kWh).

Amount of energy to power a device using 1kw for one hour. [1]

(ii) Calculate the mass of carbon dioxide saved when the wind turbine has a power output of 2000 kW and operates for 12 hours.

Energy = 2000 kw × 12 hour
= 24000 kwh.

1 kwh → 0.96 kg of CO_2
24000 kwh → ?

$\frac{24000 \times 0.96}{1}$ = 23,040 kg
= 23000 kg

mass = 23000 kg. [1]

(d) Wind energy is a form of renewable energy.

State the name of **one** other form of renewable energy.

hydroelectric, tidal, geothermal, wave, biomass, solar, [1]

[Total: 8]

3 **(a)** Define latent heat of fusion.

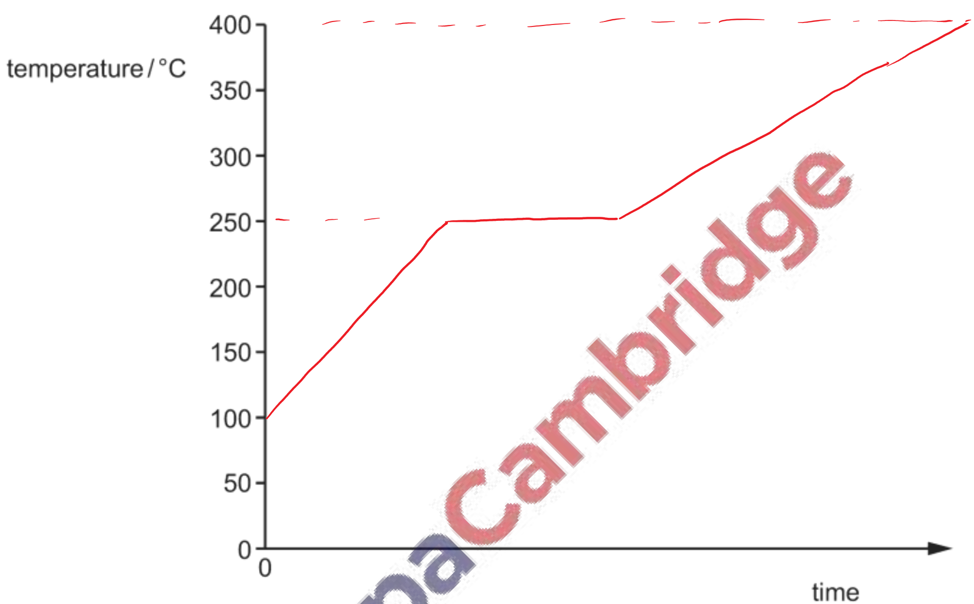
Amount of heat energy needed to the state from solid to liquid at constant temperature

[2]

(b) A sample of metal P at 100 °C is heated steadily until its temperature reaches 400 °C.

The melting point of the metal is 250 °C.

(i) On Fig. 3.1, sketch a graph to show how the temperature of the metal changes with time.



[2]

Fig. 3.1

(ii) A sample of a different metal Q has a greater latent heat of fusion than the sample of P.

↑ melt for longer time

P and Q are metals with the same melting points and the samples have the same heat capacity.

The experiment is repeated with the sample of Q. This sample is supplied with the same amount of energy per second as is supplied to the sample of P.

Explain how the graph of temperature against time for Q differs from the graph in **(b)(i)**.

– the flat section of the graph is longer at 250°C

– Since Q needs more energy to melt.

[2]

[Total: 6]

4 Two parallel rays of light, one red and one blue, enter a glass prism.

Fig. 4.1 shows both rays of light before they enter the prism. The blue ray is also shown incident on a different side of the prism after passing through the prism.

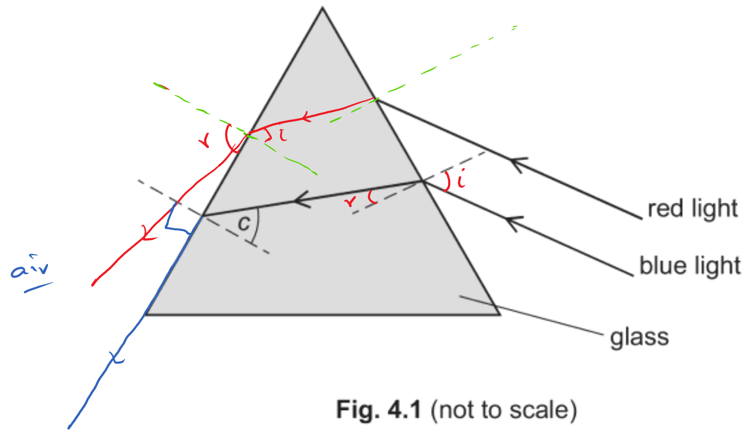


Fig. 4.1 (not to scale)

The ray of blue light strikes the left side of the prism at an angle equal to its critical angle *c*.

(a) **(i)** On Fig. 4.1, mark and label the angle of incidence *i* and the angle of refraction *r* for the blue light as it enters the prism. [1]

(ii) On Fig. 4.1, continue the path of the blue light after it strikes the left side of the prism. [1]

(iii) The refractive index of glass for red light is smaller than the refractive index for blue light.

On Fig. 4.1, draw the path of the red light as it travels in the prism and after it strikes the left side of the prism. [2]

(b) **(i)** State what is meant by the critical angle.

angle of incidence in denser medium when the angle refraction the less denser medium is 90°. [2]

(ii) The refractive index of glass for blue light is 1.5.

Calculate the critical angle *c* for blue light in glass. Show your working.

$n = \frac{1}{\sin c}$

$\sin c = \frac{1}{n}$

$= \frac{1}{1.5}$

$= 0.6666$

$c = \sin^{-1}(0.6666)$

$= 41.8$

$\simeq 42^\circ$

c = 42 [2]

[Total: 8]

5 Fig. 5.1 shows a simple d.c. motor used in a toy car.

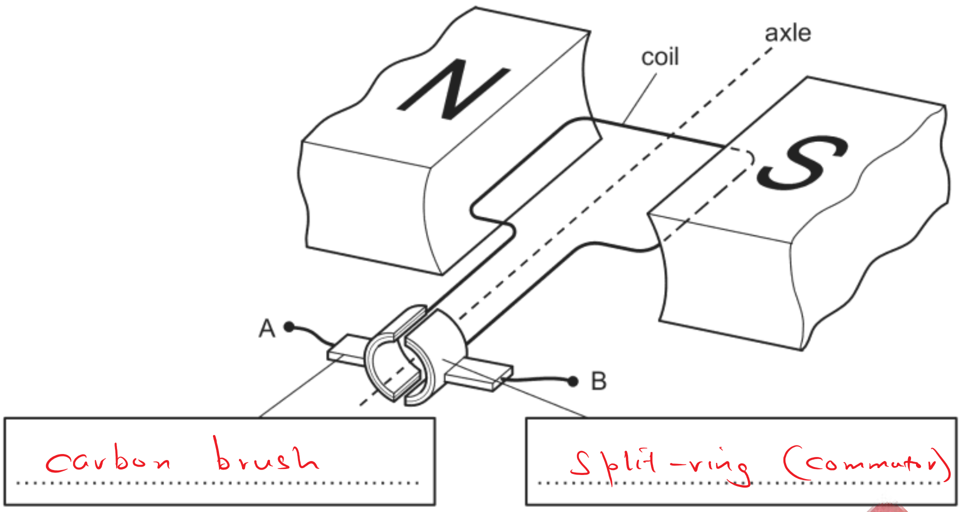


Fig. 5.1

Terminals A and B are connected to a battery and the motor rotates.

(a) On Fig. 5.1, add labels inside the boxes to identify the parts of the motor indicated. [2]

(b) State what happens to the rotation of the coil when:

(i) the number of turns on the coil is increased

faster rotation .... [1]

(ii) the magnetic field between the poles of the magnet is reversed.

rotation is reversed. .... [1]

(c) The power supply to the motor is switched on and off at a steady rate.

Fig. 5.2 shows how the speed of the toy car varies with time as a result of the power supply being switched on and off.

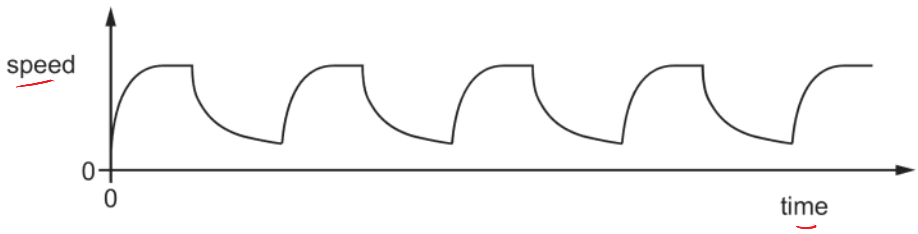


Fig. 5.2

(i) Describe the motion of the toy car.

- Speed increase and becomes steady when on.
- When off, the speed decreases when switched off
but never comes to rest.
- Then the cycles repeats again. [2]

(ii) The voltage supplied to the motor is switched on for a longer period of time and off for a longer period of time, at a steady rate.

Suggest what happens to the motion of the toy car.

- Speed reaches constant when on for long time
- When off for longer time the car comes
to a stop. [1]

[Total: 7]

6 **(a)** A light-dependent resistor (LDR) is used to sense the amount of light in a room.

Fig. 6.1 shows part of the circuit used. The LDR is not shown.

$V = V_1 + V_2$

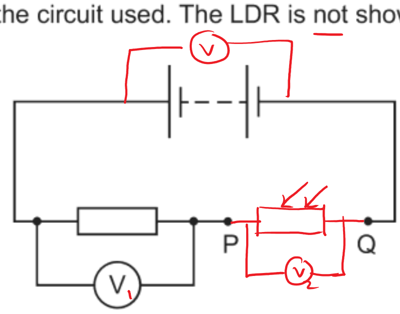


Fig. 6.1

(i) Complete Fig. 6.1 by drawing the circuit symbol for an LDR between points P and Q. [1]

(ii) Explain how the voltmeter reading changes as the amount of light falling on the LDR increases.

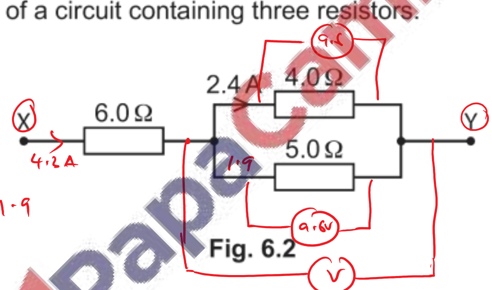
– When light is bright resistance decreases

– So more current flow in the circuit

– Voltmeter will increase. [2]

(b) Fig. 6.2 shows part of a circuit containing three resistors.

$V = I \times R$
$= 2.4 \times 4$
$= 9.6\,V$



$I = 2.4 + 1.9$
$= 4.3\,A$

Fig. 6.2

The current in the 4.0 Ω resistor is 2.4 A.

(i) Show that the current in the 5.0 Ω resistor is 1.9 A.

$I = \frac{V}{R}$
$= \frac{9.6\,V}{5\,\Omega}$
$= 1.92\,A$
$\approx 1.9\,A$

[2]

(ii) Calculate the potential difference (p.d.) between points X and Y.

$V = I \times R$
$= 4.3 \times 6.0$
$= 25.8\,V$

$R_T = \frac{4 \times 5}{4 + 5}$
$= \frac{20}{9} = 2.2\,\Omega$

$V = I \times R$
$= 4.3 \times 2.2$
$= 9.46\,V$

$V_{XY} = 25.8 + 9.46$
$= 35.26\,V$

p.d. = 35 V. [2]

[Total: 7]

Section B begins over the page

Section B

Answer **two** questions from this section. Answer in the spaces provided.

7 Fig. 7.1 shows a toy helicopter. It can hover and travel through the air.

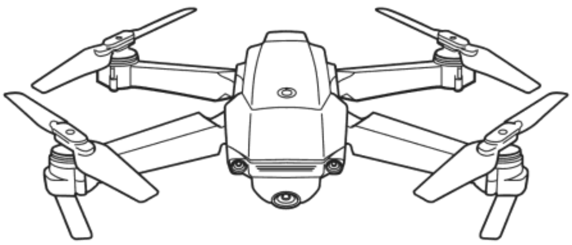


Fig. 7.1

A student flies the toy helicopter on a journey from A to B to C to D at a constant height.

Fig. 7.2 is a scale drawing of the path of the helicopter, viewed from above.

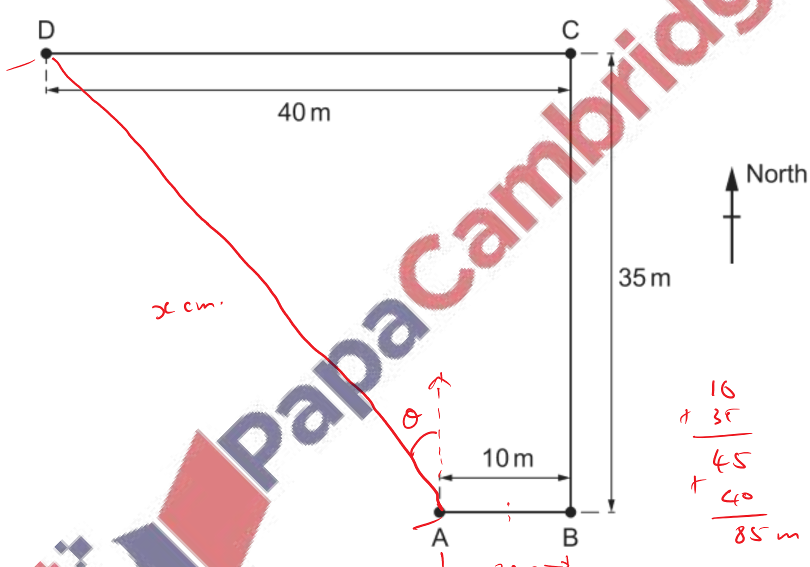


Fig. 7.2 (to scale)

(a) **(i)** Determine the total distance travelled by the toy helicopter.

85 m. .... [1]

(ii) The toy helicopter makes the journey in 40 s.

Calculate its average speed during the journey.

av. speed = total distance / total time

= 85 m / 40 s

= 2.125 m/s

speed = ...2.1 m/s............ [2]

(b) **(i)** State the difference between distance and displacement.

Displacement is a vector and so has direction

but distance has no direction. [1]

(ii) Determine the scale used to construct Fig. 7.2 and complete the sentence.

1 cm on the diagram represents ......5 m...... on the path. [1]

(iii) Using Fig. 7.2, determine the size of the displacement of point D from point A.

Show your working.

scale: 1cm = 5m.

x = 9.2cm. = ?

9.2×5 = 46m

size of displacement = ...46 m...... [2]

(iv) Determine the angle between North and the direction of the displacement of point D from point A.

angle = ...40°...... [1]

(v) State what is meant by velocity.

$v = \frac{\Delta s}{t}$

rate of change of displacement [1]

(vi) Another toy helicopter flies directly from point A to point D in 40 s.

Explain why the magnitude of the velocity of this toy helicopter is smaller than the answer in **(a)(ii)**.

the displacement is smaller than distance in (a)(ii)

∴ v = displacement / time ∴ $\frac{46}{40}$ = 1.15 m/s [1]

1.15 < 2.1

(c) When the toy helicopter hovers at D, its motor fails and it falls. It reaches terminal velocity as it falls.

Explain, in terms of the forces and acceleration, what happens as the helicopter falls and reaches terminal velocity.

- As it falls, air resistance increases, as the speed increases (accelerating).
- As the air resistance increases, the resultant force on it decreases R.F = W − a.r.
- Eventually weight = air resistance, and so the speed becomes constant at terminal velocity.
- The acceleration is zero at terminal velocity.

[5]

[Total: 15]

Question 8 begins over the page.

8 Fig. 8.1 shows a water manometer.

When the water manometer is connected to a sealed container of gas and the tap is opened, the water levels change, as shown in Fig. 8.2.

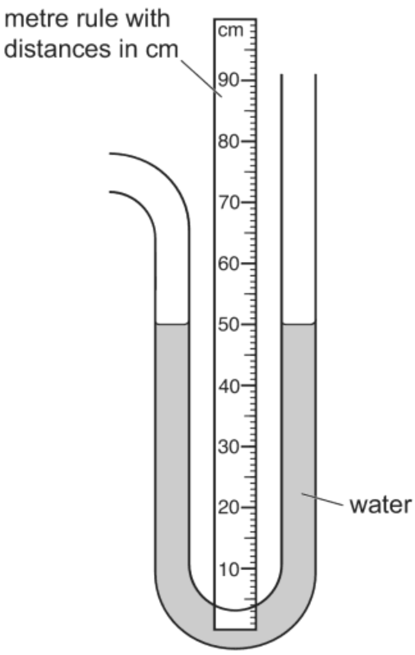


Fig. 8.1

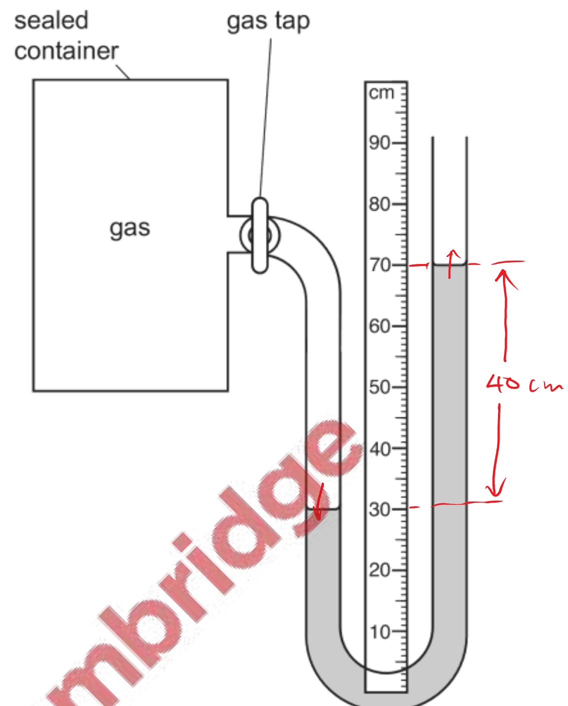


Fig. 8.2

(a) Define pressure.

force per unit area.

.... [1]

(b) (i) Explain why the water levels are the same on both sides of the manometer in Fig. 8.1.

atmospheric pressure on both sides

is equal. [1]

(ii) Explain why the water levels change when the gas tap is opened with the manometer connected as in Fig. 8.2.

pressure of gas is greater than the

atmospheric pressure. [1]

(iii) Explain why the water levels stop changing at the levels shown in Fig. 8.2.

Pressure of gas = Pressure of 40 cm of water + atm. pressure.

.... [1]

(c) The water in the manometer has a density of 1000 kg/m^3.

Atmospheric pressure is 1.00×10^5 Pa and the gravitational field strength g is 10 m/s^2.

Calculate the pressure of the gas inside the sealed container.

Give your answer to 3 significant figures.

$P_{gas} = P_{atm} + P_{water}$

$P_{water} = \rho g h$

$= 1000 \times 10 \times 0.4$

$= 4000$ Pa

$P_{gas} = 100000 + 4000$

$= 104,000$ Pa

pressure = 104,000 Pa. [4]

(d) The temperature of the gas inside the sealed container increases.

Using ideas about molecules explain why the water levels change.

- Molecules gain more K-E and move faster.
- Molecules will hit the water surface more frequently and at greater force
- This increases pressure on the water surface cause the level on the left to go down while the right goes up. [4]

(e) This manometer is not suitable for measuring a gas pressure of 2.5×10^5 Pa.

(i) Explain why.

- 2.5×10^5 Pa is much bigger than atmospheric pressure
- So the difference in height of water will be to large, but the manometer is short. So water will come out of the manometer. [2]

(ii) State **one** change to this manometer that allows it to measure a gas pressure of 2.5×10^5 Pa in a normal school laboratory.

- Use mercury since it has a large density

$\rho_{Hg} = 14000$ kg/m3, $\rho_{H_2O} = 1000$ kg/m3 [1]

So Mercury is about 14 time more denser than water.

[Total: 15]

9 Table 9.1 shows details of seven different nuclides.

Table 9.1

nuclide	radiation emitted	half-life
hydrogen-2	none	–
hydrogen–3	beta	12 year
francium-223	beta	22 min
iridium-192	gamma	74 day
phosphorus-32	beta	14 day
radon−222	alpha	4 day
technetium-99	gamma	6 hour

(a) (i) Hydrogen-2 and hydrogen-3 are isotopes of the element hydrogen.

Define the term isotope.

The nucleus have same number of protons but different number of neutrons ..... [2]

(ii) The equation for the decay of phosphorus-32 (P-32) as it emits a beta particle is:

$$^{32}_{15}P \rightarrow \; ^{0}_{-1}\beta + \; ^{32}_{16}Q$$

↑protons ↑protons

Explain whether the equation shows that Q is another isotope of phosphorus. Q is not the chemical symbol for the atom.

– Q is not an isotope P, since it has different number of protons ..... [1]

(b) One of the sources in Table 9.1 is used in a medical procedure to detect unusual bone structures. It is injected into a patient and the radiation emitted is detected outside the body.

(i) State which source in Table 9.1 is most suitable for this type of medical use.

technetium – 99 ..... [1]

(ii) Explain **two** reasons for your choice

– Emits gamma, which can penetrate through the skin and bone to come outside the body.

– Has a short half-life of 6 hours, so it does not stay longer inside the body; so does not do any more damage to body organs. [2]

(c) Radon gas is one natural source of background radiation.

Some causes of background radiation are man-made, for example, X-rays.

(i) State one other **natural** source of background radiation.

Cosmic ray, rocks, building. [1]

(ii) State one other **man-made** source of background radiation.

nuclear power stations, nuclear weapons. [1]

(iii) State one **harmful** effect of background radiation.

Cancer and cell mutation [1]

(d) One fusion reaction that occurs is:

$$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}X$$

$^{0}_{-1}e$

$^{1}_{1}p$

(i) Complete the equation to show the missing proton and nucleon numbers. [1]

(ii) Deduce the name of particle X.

neutron. [1]

(iii) Suggest where this fusion reaction takes place.

Sun and the stars, where the temperature are very high. [1]

(e) Compare the properties of alpha-particles and beta-particles in terms of their:

- ability to penetrate through materials
- ionising effects
- deflection in a magnetic field.

- beta-particles are more penetrating than alpha, since α are stopped by paper but β are stopped by thin aluminium foil
- α-particle are more ionising than Beta.
- α is +vely and β is −vely charged.
- Both deflected in opposite sides in magnetic field.
- But β is deflected more than α, since it is lighter. [3]

[Total: 15]

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