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CANDIDATE NAME

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3311155151511

CO-ORDINATED SCIENCES **0654/41**

Paper 4 Theory (Extended) **May/June 2026**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** 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. Do **not** use correction fluid or tape.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.
- Take the weight of 1.0 kg to be 9.8 N (acceleration of free fall = 9.8 m / s^2).

INFORMATION

- The total mark for this paper is 120.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.

This document has **28** pages. Any blank pages are indicated.

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1 Maize is grown as a source of food in many countries.

(a) Maize is a wind-pollinated plant species.

Figure 1.1 shows the reproductive parts of the maize plant.

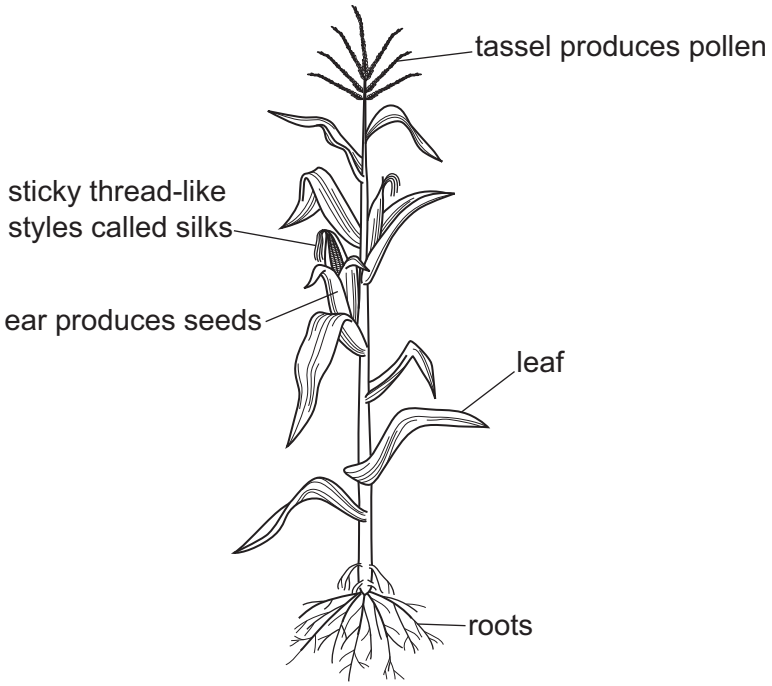


Figure 1.1

(i) Identify the part labelled in Figure 1.1 that produces the male gamete.

Circle the correct answer.

ear **leaf** **silk** **tassel**

[1]

(ii) Suggest **one** way that the maize plant in Figure 1.1 is adapted for wind pollination.

.....

..... [1]

(iii) The gametes in maize contain 10 chromosomes.

Complete the sentences about diploid maize cells.

In a diploid cell, there is a ..... of each type of chromosome.

In a maize diploid cell, there are ..... chromosomes in total.

[2]

(iv) State the type of cell division used to produce gametes.

..... [1]

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(b) The seeds produced by maize plants are either round or wrinkled.

Two maize plants with round seeds are crossed.

Some of the offspring are maize plants that produce wrinkled seeds.

(i) Complete the Punnett square in Figure 1.2 to show how maize plants with **round** seeds produce maize plants with **wrinkled** seeds.

The allele for round seeds is **R**.
The allele for wrinkled seeds is **r**.

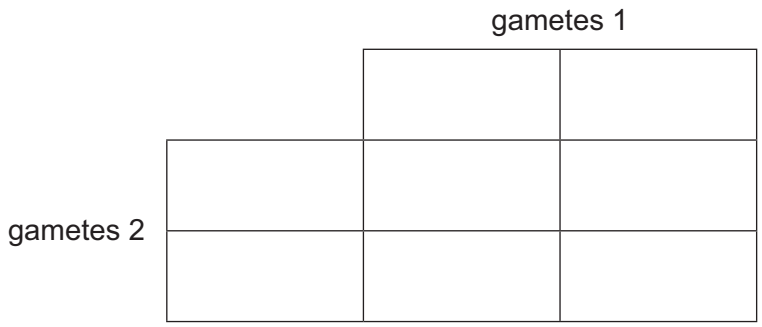


Figure 1.2

[2]

(ii) A farmer crosses heterozygous maize plants with round seeds to produce 100 new maize plants.

Predict approximately how many of these new maize plants will have wrinkled seeds.

..... [1]

[Total: 8]

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2 The human digestive system uses enzymes for chemical digestion.

(a) State the role of chemical digestion in the human body.

.....

.....

..... [2]

(b) The chemical digestion of fats produces fatty acids.

Name the **other** product from the digestion of fats.

..... [1]

(c) A student investigates the effect of different enzymes on the digestion of fats in milk.

The student uses a pH indicator that changes from pink to colourless when fatty acids are produced.

The student has three test-tubes and puts milk, sodium carbonate and the indicator into each test-tube. The student then adds a different enzyme to each test-tube.

Table 2.1 shows the colour of the indicator in each test-tube at the start and after 5 minutes.

Table 2.1

	enzyme		
	lipase	**protease**	**amylase**
colour of indicator at start	pink	pink	pink
colour of indicator after 5 minutes	colourless	pink	pink

(i) Explain the results shown in Table 2.1.

Include ideas about active sites in your answer.

.....

.....

.....

.....

.....

..... [3]

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(ii) State **one** part of the human digestive system where amylase is secreted and the part where this amylase acts.

secreted .....

acts .....

[2]

(d) In the human body, a mixture is added to fats to increase their surface area for chemical digestion.

State the name of this mixture.

..... [1]

(e) The stomach of the human digestive system contains hydrochloric acid.

Describe the functions of the acid in the stomach.

.....

.....

..... [2]

[Total: 11]

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3 Figure 3.1 shows a food web from an aquatic ecosystem.

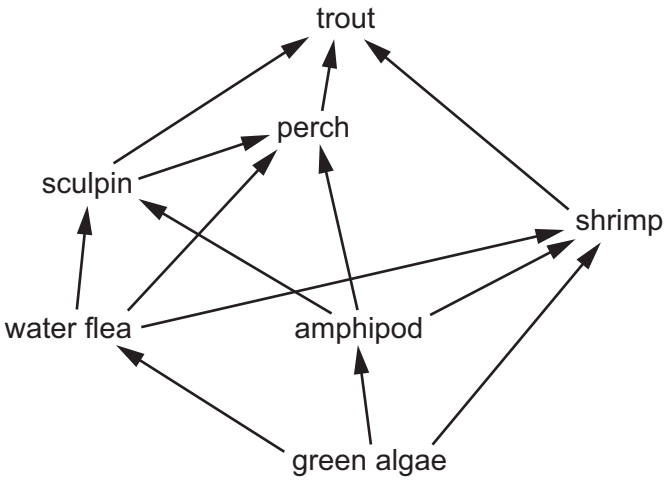


Figure 3.1

(a) Place ticks (✓) in **all** the boxes that describe the **perch** in Figure 3.1.

carnivore	☐
consumer	☐
decomposer	☐
herbivore	☐
2nd trophic level	☐
3rd trophic level	☐
4th trophic level	☐

[2]

(b) The longest food chains in this food web have five trophic levels.

(i) Write down a food chain from Figure 3.1 with **five** trophic levels.

..... [1]

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(ii) Explain why food chains usually have fewer than five trophic levels.

.....

.....

.....

.....

.....

..... [3]

(c) The cells in algae have a similar structure to plant cells.

The cells in algae contain chloroplasts for photosynthesis.

(i) State **one** other structure in a cell of algae which is **not** present in an animal cell.

..... [1]

(ii) State the balanced symbol equation for photosynthesis.

..... + ... → ..... + ... [2]

[Total: 9]

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4 Polio is a disease caused by a virus.

The polio virus can be passed from one person to another through faeces or droplets of body fluids.

(a) Circle the term that describes a disease that is passed from one person to another.

digestive **homeostatic** **resistant** **transmissible**

[1]

(b) The polio virus has the features of a typical virus.

Complete the sentence about the polio virus.

The polio virus is made of ..... material surrounded by a coat made of ..... .

[2]

(c) The polio virus sometimes affects the central nervous system.

State the name of **one** part of the central nervous system.

..... [1]

(d) People in many countries are vaccinated against polio.

(i) The vaccine produces active immunity in the body.

Complete the sentences to describe how the body responds to the vaccine to produce active immunity.

Antigens in the vaccine stimulate an ..... response, causing ..... to produce antibodies.

Antibodies have ..... shapes to fit specific antigens.

..... cells are produced that give long-term immunity.

[3]

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(ii) Figure 4.1 shows the number of cases of polio in one country from 1910 to 2020.

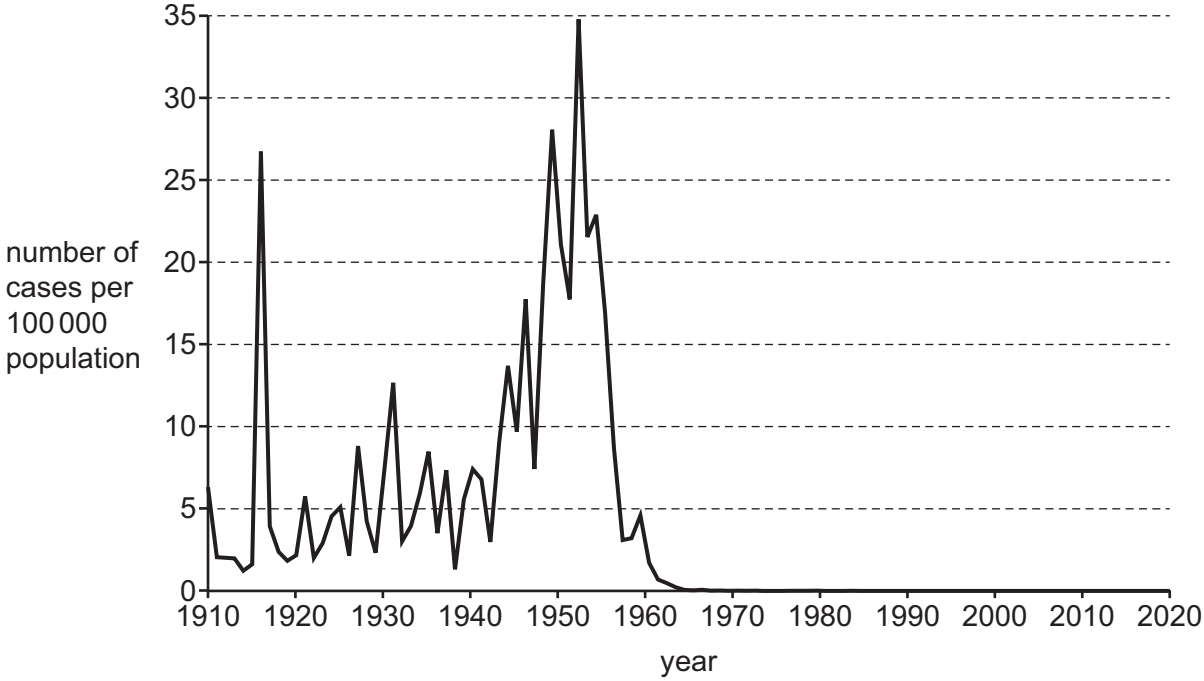


Figure 4.1

The polio vaccine was first produced in 1955.

Explain the role of vaccination in controlling the spread of polio.

Use data from Figure 4.1.

.....

.....

.....

.....

.....

..... [3]

(iii) In the country, each child is given four doses of polio vaccine.

The fertility rate in the country in 2022 was 56 births per 1000 women aged 18–44.

There were 6.55×10^7 women aged 18–44 in the country in 2022.

Use calculations to estimate the number of doses of polio vaccine needed to fully vaccinate the children born in 2022.

Assume each birth is just one baby.

..... doses of polio vaccine [2]

[Total: 12]

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5 Figure 5.1 shows the structure of an atom of an element, **X**.

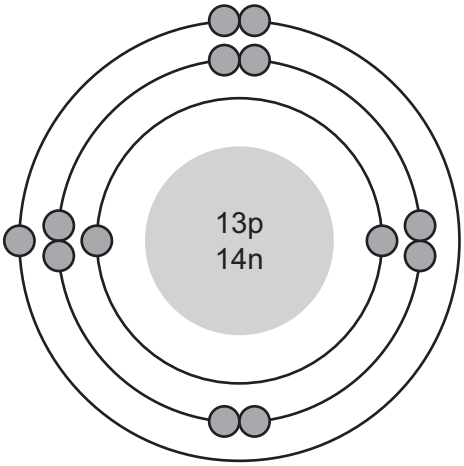


Figure 5.1

(a) (i) State the **atomic number** of element **X**.

..... [1]

(ii) State the **mass number** of element **X**.

..... [1]

(iii) Explain why element **X** is in Period 3 of the Periodic Table.

.....

..... [1]

(b) Element **X** is a metal.

Explain why metals have good electrical conductivity.

.....

.....

..... [2]

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(c) Figure 5.2 shows part of the reactivity series.

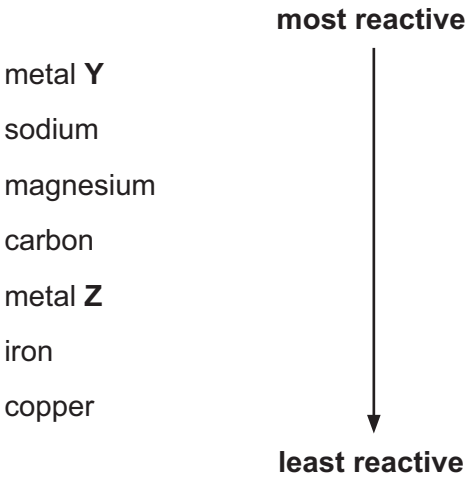


Figure 5.2

Draw **one** line from each metal to the method used to extract the metal.

Use Figure 5.2 to help you.

metal	**method used to extract the metal**
metal **Y**	extracted by electrolysis of a molten ionic compound
metal **Z**	extracted from its oxide by reduction with carbon
	extracted from the Earth as pure metal

[2]

(d) Iron reacts with dilute hydrochloric acid.

Aqueous iron chloride and **one** other product are made.

State the name of the other product.

..... [1]

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(e) Magnesium reacts with aqueous iron chloride.

$$3Mg + 2FeCl_3 \rightarrow 2Fe + 3MgCl_2$$

0.6 g of magnesium reacts with excess aqueous iron chloride.

Calculate the maximum mass of iron that is made.

[A_r: C*l*, 35.5; Fe, 56; Mg, 24]

mass of iron = ... g [3]

[Total: 11]

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6 **(a)** The reaction between chlorine, Cl_2, and sodium iodide, NaI, has a low activation energy.

State what is meant by activation energy.

.....

.....

..... [2]

(b) Complete the balanced symbol equation for the reaction between chlorine, Cl_2, and sodium iodide, NaI.

$$Cl_2 + 2NaI \rightarrow \text{.....} + \text{.....}$$

[2]

(c) Complete the dot-and-cross diagram in Figure 6.1 to show the bonding in chlorine, Cl_2.

Only show the outer-shell electrons.

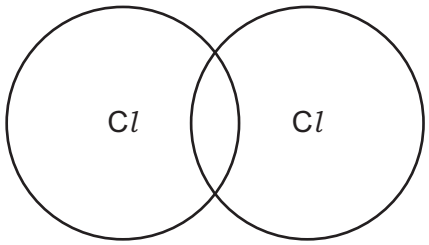


Figure 6.1

[2]

(d) Chlorine, Cl_2, is a simple covalent molecule.

Sodium iodide, NaI, is an ionic compound.

Chlorine melts at –102 °C.

Sodium iodide melts at 661 °C.

Explain the difference in the melting points in terms of attractive forces.

.....

.....

.....

.....

..... [3]

[Total: 9]

7 A student investigates the reaction between magnesium carbonate and dilute hydrochloric acid.

$$MgCO_3 + 2HCl \rightarrow MgCl_2 + H_2O + CO_2$$

Carbon dioxide gas is made in the reaction.

(a) Describe the test for carbon dioxide gas and give the observation for a positive result.

test .....

observation .....

[2]

(b) The student uses dilute hydrochloric acid at a temperature of 50 °C.

The student measures the total loss in mass of the reaction mixture every 25 seconds for 150 seconds.

Figure 7.1 shows a graph of the results.

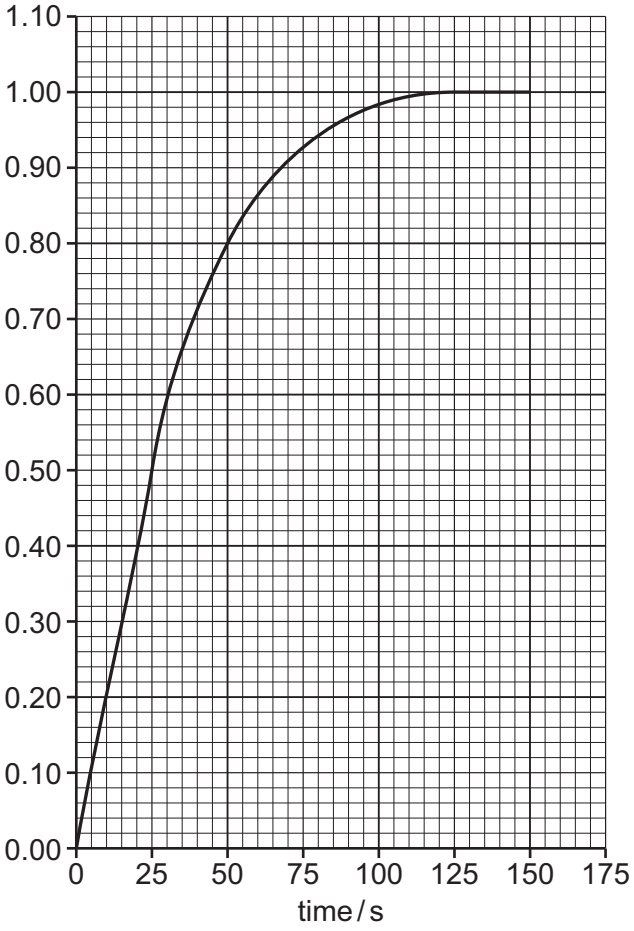


Figure 7.1

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Use Figure 7.1 and a tangent line to calculate the rate of reaction when the total loss in mass is 0.95 g.

rate of reaction = ... g / s [4]

(c) The student repeats the experiment using dilute hydrochloric acid at a temperature of **30 °C**.

All other conditions remain the same.

Describe how the shape of the graph in Figure 7.1 would be different at 30 °C.

.....

.....

..... [2]

(d) The reaction makes 1.00 g of carbon dioxide gas.

Calculate the volume of carbon dioxide gas made at room temperature and pressure.

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

[M_r: CO_2, 44]

volume of carbon dioxide = ... dm^3 [3]

[Total: 11]

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8 **(a)** Natural gas is a fossil fuel.

State the name of **one** other fossil fuel.

..... [1]

(b) Methane is the main constituent of natural gas.

Draw the displayed formula of methane.

[1]

(c) Methane is a small alkane molecule.

Large alkane molecules can be cracked to make an alkene and a smaller alkane.

(i) Complete the equation for the cracking of $C_{14}H_{30}$.

$$C_{14}H_{30} \rightarrow C_4H_8 + ...$$

[1]

(ii) C_4H_8 is butene.

Complete Figure 8.1 to show the displayed formula for but-1-ene.

C C C C

Figure 8.1

[2]

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(iii) State the type of bond in a molecule of but-1-ene.

Choose from the list.

covalent

intermolecular

ionic

metallic

..... [1]

(d) Methane is produced by the decomposition of vegetation.

State one other source of methane.

Tick (✓) **one** box.

complete combustion of carbon-containing fuels	☐
reaction of an alkene with steam	☐
reaction of an alkene with hydrogen	☐
waste gases from digestion in animals	☐

[1]

(e) Higher levels of methane in the atmosphere lead to increased global warming.

Global warming leads to climate change.

State **two** ways to reduce the effects of climate change.

1 .....

.....

2 .....

.....

[2]

[Total: 9]

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9 **(a)** Figure 9.1 shows a toy car travelling along a straight horizontal track across a table.

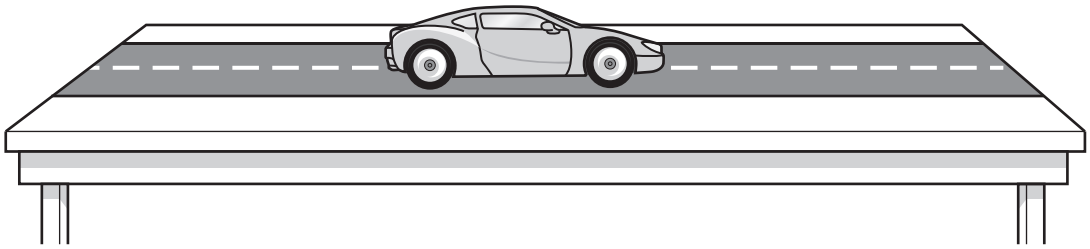


Figure 9.1

(i) Name an instrument suitable for measuring the time taken for the car to travel along the track.

..... [1]

(ii) The car travels 2.4 m in 4.4 s.

Calculate the average velocity of the car.

velocity = ... m/s [2]

(iii) The car is initially at rest. It has a constant acceleration of 0.85 m/s^2 for the first 2.0 s.

Calculate the velocity of the car at 2.0 s.

velocity = ... m/s [2]

(iv) On Figure 9.2, sketch a velocity–time graph for the car during the first 2.0 s.

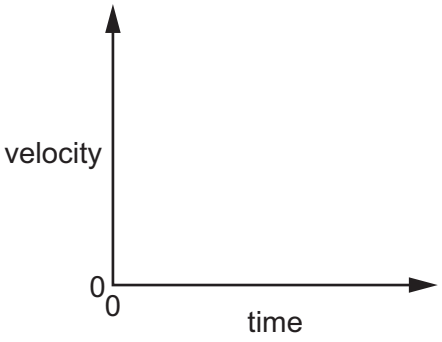


Figure 9.2

[1]

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(b) The velocity of the car decreases.

The car just reaches the edge of the table with a horizontal velocity of 0 m / s as it starts to fall vertically downwards.

This is shown in Figure 9.3.

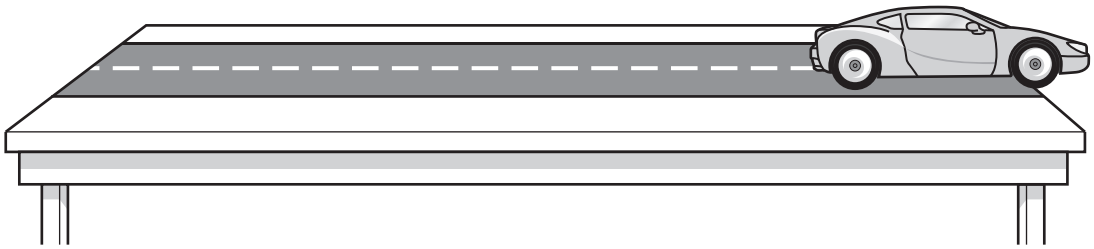


Figure 9.3

(i) State the magnitude of the vertical acceleration of the car.

..... [1]

(ii) The car falls a distance of 0.75 m to the ground.

All of the energy in the gravitational potential store of the car moves to the kinetic store.

Calculate the vertical velocity of the car just as it hits the ground.

vertical velocity = ... m / s [3]

[Total: 10]

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10 **(a)** A sealed bottle contains some gas.

(i) The bottle contains 1.4 g of the gas in a volume of 900 cm^3.

Calculate the density of the gas.

density = ... g/cm^3 [2]

(ii) Describe how the gas exerts a pressure on the bottle.

.....

.....

.....

.....

..... [3]

(b) A bottle is filled with water.

An electric heater is used to heat the water.

(i) The current in the heater is 2.5 A.

The potential difference across the heater is 12 V.

Calculate the power of the heater.

power = ... W [2]

(ii) The water changes state by both boiling and evaporation.

State **two** differences between boiling and evaporation.

1 .....

.....

2 .....

.....

[2]

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(iii) The heater is a resistor.

On Figure 10.1, sketch the current–voltage graph for a resistor of constant resistance.

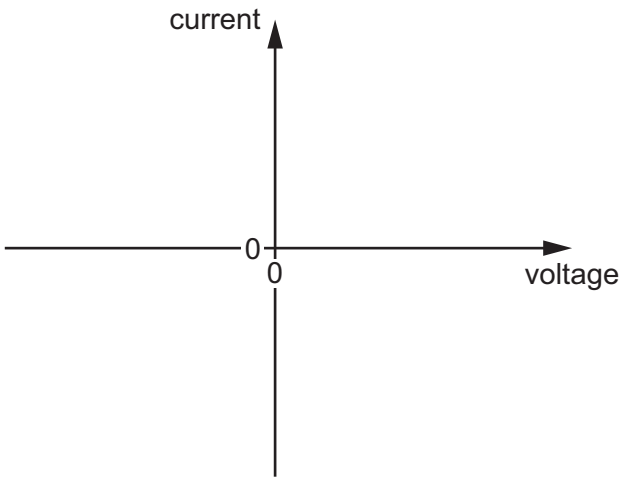


Figure 10.1

[1]

[Total: 10]

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11 (a) (i) Describe a longitudinal wave.

.....

.....

..... [2]

(ii) Give **two** examples of longitudinal waves.

1 .....

2 .....

[2]

(b) Figure 11.1 shows sound waves travelling from left to right as they approach a gap in a barrier.

On Figure 11.1, draw **three** additional waves to show diffraction of the waves as they pass through the gap.

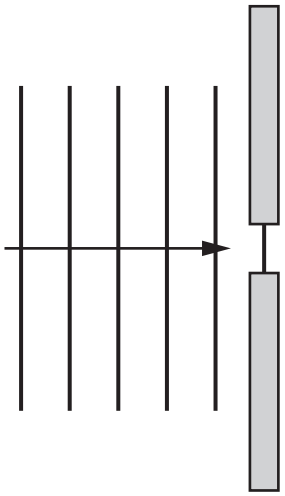


Figure 11.1

[2]

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(c) Figure 11.2 shows a ray of light travelling in air.

The ray is incident on the surface of a transparent liquid.

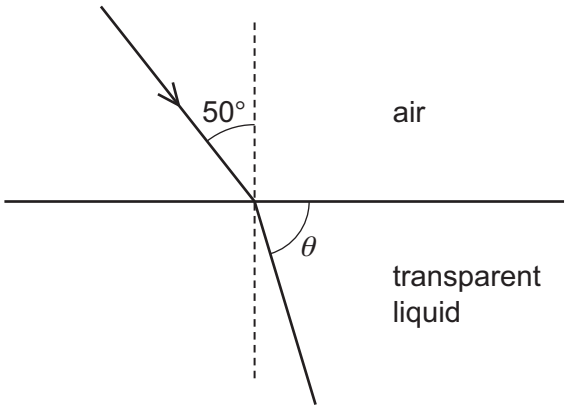


Figure 11.2

The refractive index of the liquid is 1.52.

Calculate the angle θ.

θ = ...° [4]

[Total: 10]

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12 (a) (i) State the name of the force which keeps the Earth in orbit around the Sun.

..... [1]

(ii) State how the strength of this force changes, if at all, as distance from the Sun increases.

..... [1]

(iii) Describe the process which causes the release of energy in stars.

.....

.....

..... [2]

(iv) The Moon orbits the Earth at a distance of 380 000 km in 27 days.

Calculate the orbital speed of the Moon in its orbit of Earth.

orbital speed = ... m / s [3]

(b) A scientist finds an old shell that they believe is 28 500 years old.

The scientist compares a sample of the old shell with a sample of the same mass from a living shell.

The living shell measures a count rate of 307 counts / minute due to the decay of the radioactive isotope, carbon-14.

The half-life of carbon-14 is 5700 years.

Calculate the count rate expected from the old shell if it is 28 500 years old.

count rate = ... counts / minute [3]

[Total: 10]

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The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

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