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CANDIDATE NAME

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07030272172

CO-ORDINATED SCIENCES **0654/42**

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 **32** pages.

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1 Figure 1.1 shows some of the cells in part of a leaf.

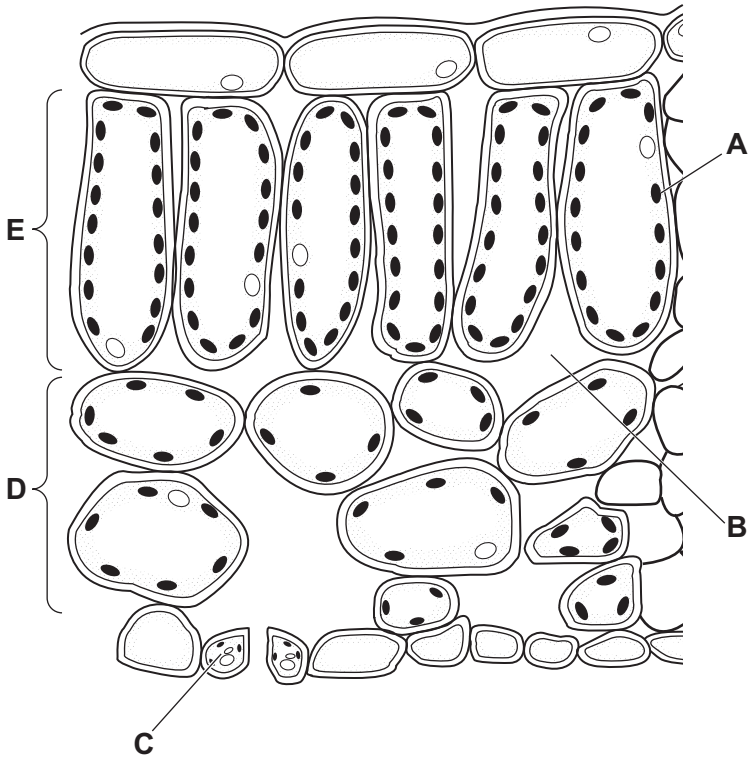


Figure 1.1

(a) Name the cell labelled **C** in Figure 1.1.

..... [1]

(b) Name the pigment that is found in the part labelled **A** in Figure 1.1.

..... [1]

(c) Describe how the layers labelled **D** and **E** in Figure 1.1 adapt the leaf for photosynthesis.

D .....

.....

.....

E .....

.....

.....

[4]

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(d) (i) Carbon dioxide is found in the air spaces in plant leaves.

State the test for carbon dioxide.

..... [1]

(ii) A scientist compares the concentration of carbon dioxide in air samples from the:

- air spaces in plant leaves
- gas exchange system in the human body.

Complete Table 1.1 to predict if the concentration of carbon dioxide will be **higher**, **lower** or the **same** compared to atmospheric air.

Table 1.1

location	concentration of carbon dioxide
air spaces in plant leaves at night	
air spaces in plant leaves in the day	
inspired air in the human airways	
expired air from the human lungs	

[2]

(e) Figure 1.2 shows the view of stomata on a leaf using a light microscope.

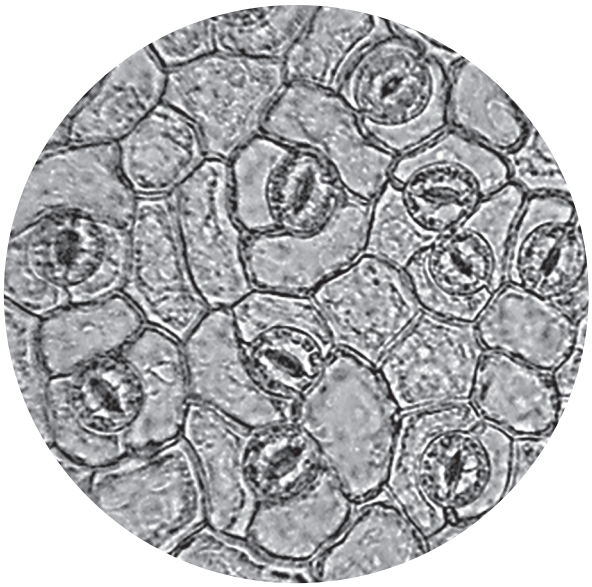


Figure 1.2

The scientist calculates the density of stomata on the leaf.

The scientist uses two formulas:

$$\text{density of stomata} = \frac{\text{number of stomata}}{\text{area}}$$

$$\text{area of circle} = \pi r^2 \quad (\pi = 3.14)$$

There are 10 stomata in Figure 1.2.

The diameter of the circle in Figure 1.2 is 0.45 mm.

Calculate the density of stomata on the leaf in Figure 1.2.

Give your answer to the nearest whole number of stomata.

density of stomata = ... stomata per mm^2 [2]

[Total: 11]

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Turn over

2 Figure 2.1 shows the control of blood glucose concentration in the human body.

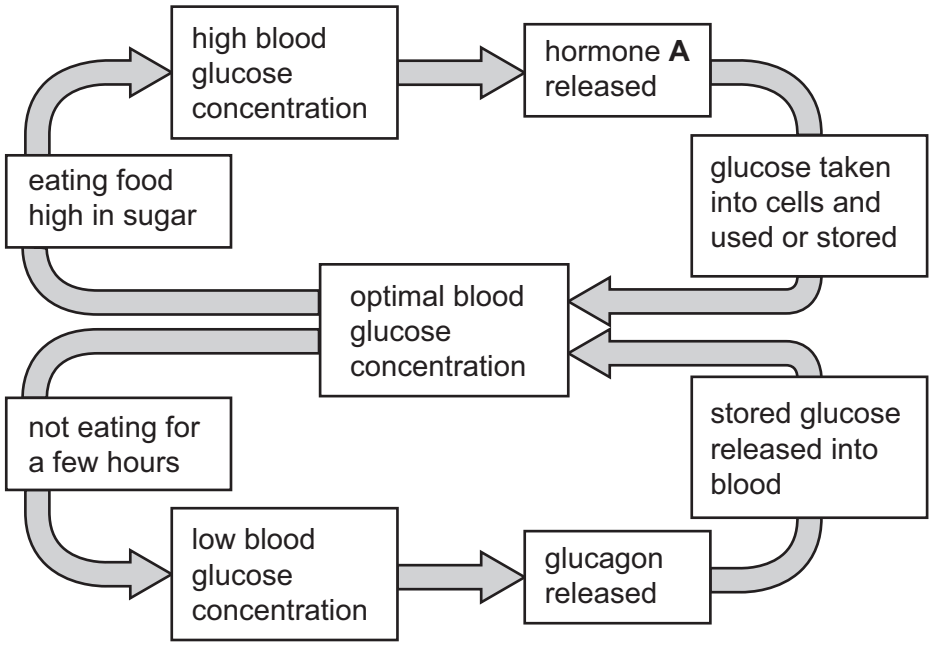


Figure 2.1

(a) Identify hormone **A** in Figure 2.1.

..... [1]

(b) Complete the sentence about the storage of glucose.

Choose words from the list.

cellulose **glycogen** **kidney** **liver**

starch **stomach** **sucrose**

Glucose is stored as ..... in the..... .

[2]

(c) Name the organ that secretes glucagon.

..... [1]

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(d) The control of blood glucose concentration is an example of negative feedback.

Use Figure 2.1 to describe how negative feedback is used to control blood glucose concentration.

.....

.....

.....

.....

.....

..... [3]

[Total: 7]

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3 A farmer selectively breeds different types of chicken.

Table 3.1 shows some information about the chickens.

Table 3.1

type of chicken	average number of eggs laid per month	average mass of eggs / g	average mass of chicken / kg
A	24	60	2.4
B	27	59	2.7
C	23	49	3.1
D	25	72	2.4

(a) The farmer decides to breed a new type of chicken.

This new type of chicken will produce:

- a higher number of eggs per month
- eggs with a higher mass.

Describe how to use selective breeding to produce this new type of chicken.

Identify the **two** types of chicken from Table 3.1 the farmer should use.

types of chicken from Table 3.1 ..... and .....

description of selective breeding .....

.....

.....

.....

.....

[4]

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(b) Table 3.2 shows information about pathogens in four of the farmer's chickens.

Table 3.2

chicken	pathogen present
W	none
X	viral
Y	none
Z	bacterial

The farmer wants to give antibiotics to **all four** chickens shown in Table 3.2.

A vet (doctor for animals) recommends that **only** chicken **Z** should be given antibiotics.

Explain why **only** chicken **Z** should be given antibiotics.

.....

.....

..... [2]

(c) **(i)** Draw **one** straight line to link each bacterial cell structure to its function.

bacterial cell structure	function
cell wall	contains extra genes
plasmid	maintains shape of the cell
ribosome	site of protein synthesis

[2]

(ii) Bacteria are important in the carbon cycle.

Figure 3.1 shows a simplified carbon cycle.

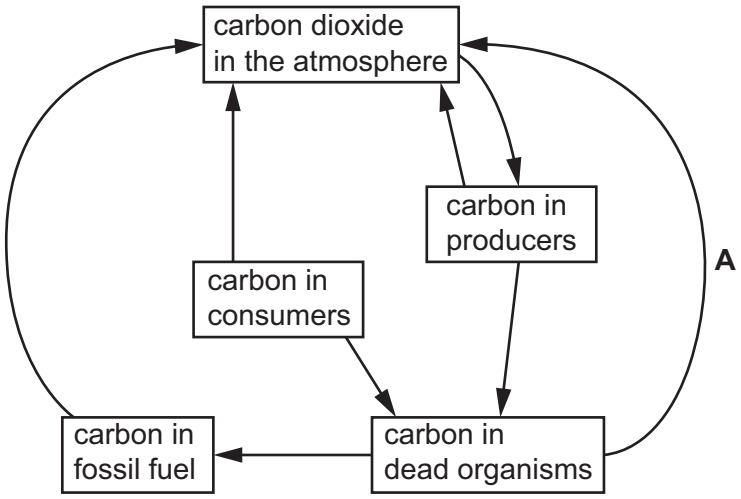


Figure 3.1

Bacteria are involved in process **A**.

State the name of process **A** and explain why process **A** is important in food chains.

name .....

explanation .....

.....

.....

.....

[3]

[Total: 11]

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4 Humans reproduce sexually.

(a) Complete the sentences to describe sexual reproduction in humans.

Sexual reproduction involves gametes and fertilisation.

Fertilisation is the fusion of the ..... of two gametes to form a ..... which is a diploid cell.

Gametes are cells which have 23 chromosomes so they are ..... .

[3]

(b) Figure 4.1 shows the structure of a human egg cell.

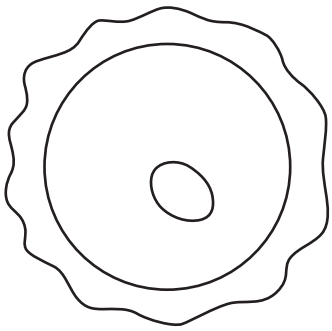


Figure 4.1

(i) Explain how a human egg cell is adapted for its function.

.....

.....

..... [2]

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(ii) Table 4.1 shows some information about male and female gametes.

Table 4.1

feature	male gamete	female gamete
size / mm	0.05	0.1
average number produced in one event	100 million	1

Describe **three** differences between male and female gametes.

Use information from Table 4.1 and your own knowledge.

1 .....

.....

2 .....

.....

3 .....

.....

[3]

(c) Other organisms reproduce asexually.

(i) Describe asexual reproduction.

.....

.....

..... [2]

(ii) Explain **one** disadvantage of asexual reproduction to a population of a species in the wild.

.....

..... [1]

[Total: 11]

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5 Nitrogen is a gas at room temperature.

(a) In nitrogen gas, the nitrogen molecules are arranged randomly and far apart.

The molecules move quickly.

Describe the arrangement and movement of the molecules in **solid** nitrogen.

arrangement .....

.....

movement .....

.....

[2]

(b) The relative rate of diffusion of hydrogen gas is greater than that of nitrogen gas.

Explain why.

.....

.....

..... [2]

(c) Clean, dry air contains approximately 78% nitrogen.

State the percentage of oxygen in clean, dry air.

.....% [1]

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(d) Oxides of nitrogen form in car engines.

(i) Describe how oxides of nitrogen form in car engines.

.....

..... [1]

(ii) Oxides of nitrogen are removed by catalytic converters.

Complete the balanced symbol equation for the reaction that takes place.

2CO + ... → ..... + ...

[2]

(e) Complete the dot-and-cross diagram in Figure 5.1 to show the bonding in nitrogen, N_2.

Only show the outer-shell electrons.

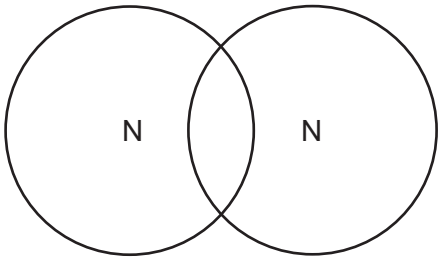


Figure 5.1

[2]

[Total: 10]

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6 **(a)** Copper is a transition element.

Potassium is a Group 1 element.

Identify two correct differences between copper and potassium.

Tick (✓) **two** boxes only.

copper has a lower melting point ☐

copper is softer ☐

copper is more dense ☐

copper is less reactive ☐

copper is less strong ☐

[2]

(b) Neon has the atomic number 10.

Explain why neon does **not** form compounds.

Use ideas about electrons.

.....

.....

..... [2]

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(c) Figure 6.1 shows an outline of the Periodic Table.

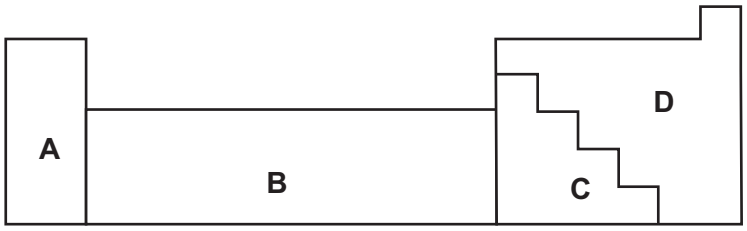


Figure 6.1

Element **X**:

- is a blue-grey solid
- does **not** conduct electricity
- forms an acidic oxide.

State which section of the Periodic Table is most likely to contain element **X**.

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

[1]

(d) A magnesium atom has an atomic number of 12 and a mass number of 24.

Complete Figure 6.2 to show the electronic configuration of a magnesium atom.

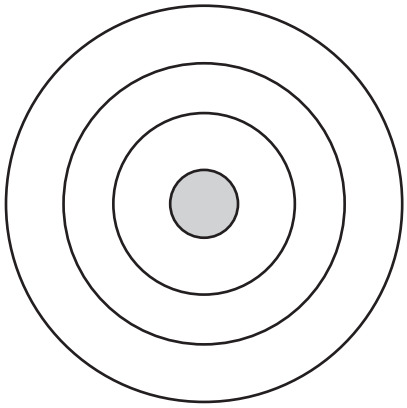


Figure 6.2

[1]

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(e) Magnesium is a metal.

Magnesium is malleable.

Describe how the structure and bonding of magnesium causes it to be malleable.

Use ideas about structure and bonding.

.....

.....

..... [1]

(f) Oxygen is a non-metal.

Magnesium reacts with oxygen to form magnesium oxide.

(i) State the type of bonding in magnesium oxide.

..... [1]

(ii) Describe what happens when a magnesium atom bonds with an oxygen atom.

Use ideas about electrons in your answer.

.....

.....

.....

..... [3]

[Total: 11]

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7 A student investigates the reaction between dilute hydrochloric acid and aqueous sodium thiosulfate.

A yellow solid, sulfur, is made in the reaction.

(a) Complete the state symbol for sulfur, S, in the balanced symbol equation.

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + SO_2(g) + S(.....)$$

[1]

(b) Figure 7.1 shows the student's experiment.

A cross, **X**, is visible, marked on paper below the flask.

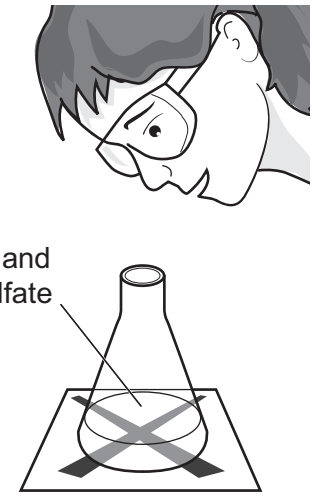


Figure 7.1

As the product is made, the liquid in the conical flask goes cloudy.

After a time, the student cannot see the cross.

The student measures this time.

The student does four experiments, all at 25 °C.

The student uses four different concentrations of sodium thiosulfate, **A**, **B**, **C** and **D**.

Table 7.1 shows the student's results.

Table 7.1

concentration	time for X to disappear / s
A	42
B	71
C	124
D	63

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(i) Identify which concentration of aqueous sodium thiosulfate gave the **fastest** reaction.

..... [1]

(ii) Identify the **least concentrated** solution of aqueous sodium thiosulfate.

.....

Explain your answer.

.....

.....

[2]

(c) The student dilutes the aqueous sodium thiosulfate using distilled water.

Explain why the student uses distilled water rather than tap water.

.....

..... [1]

(d) The student repeats the experiment using concentration **C**.

This time, they do the experiment at **40 °C**.

(i) Suggest how long it will take for the **X** to disappear.

time for **X** to disappear = ... s [1]

(ii) Explain your answer using collision theory.

.....

.....

.....

..... [3]

(e) Sulfur dioxide is an air pollutant.

Complete the sentence to describe the reaction that produces sulfur dioxide to cause air pollution.

Sulfur dioxide is produced from the ..... of fossil fuels

which contain ..... compounds.

[2]

[Total: 11]

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8 Figure 8.1 shows some reactions of ethene.

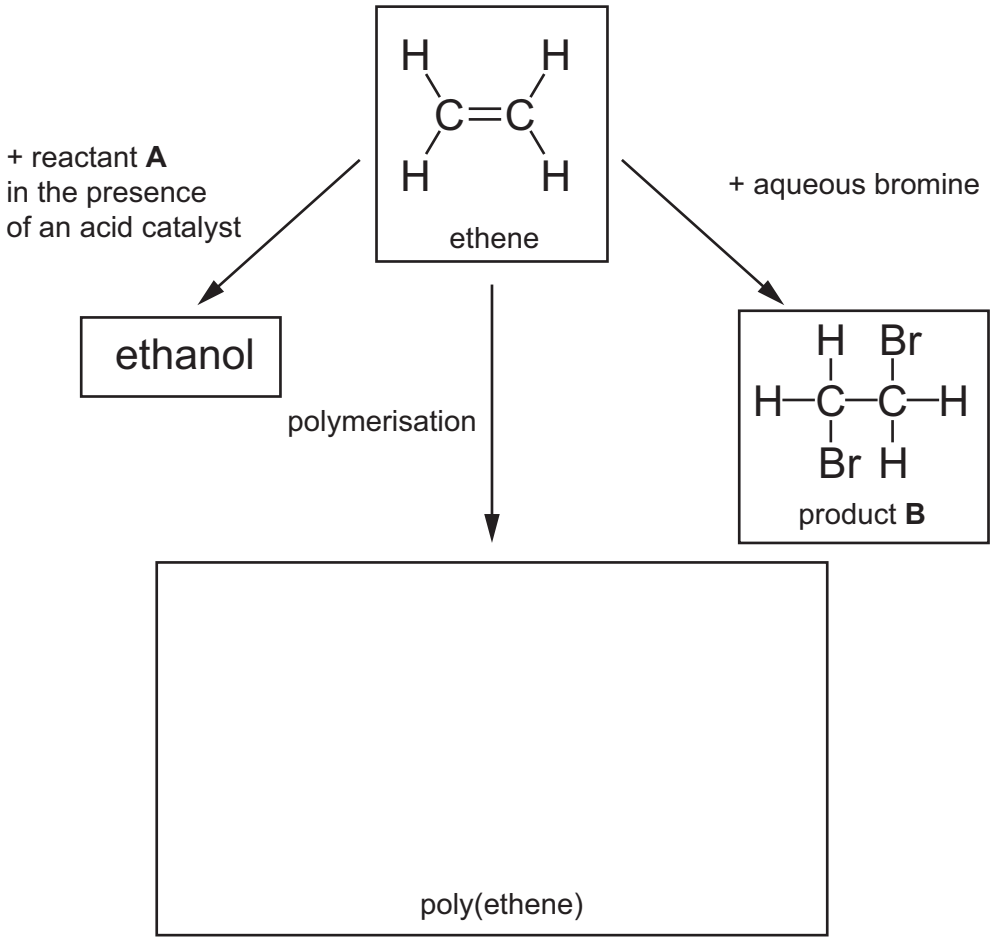


Figure 8.1

(a) (i) State the name of reactant **A**.

..... [1]

(ii) Poly(ethene) is made by addition polymerisation of ethene monomers.

Draw the structure of poly(ethene) in the box on Figure 8.1. [2]

(iii) State the colour change, if any, when orange aqueous bromine is added to ethene to make product **B**.

..... [1]

(b) Ethene reacts with hydrogen to make ethane, C_2H_6.

Ethane undergoes complete combustion.

Write the balanced symbol equation for the complete combustion of ethane.

..... + ... → ..... + ...

[2]

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(c) Ethane is obtained from the fractional distillation of petroleum.

Figure 8.2 shows a fractionating column.

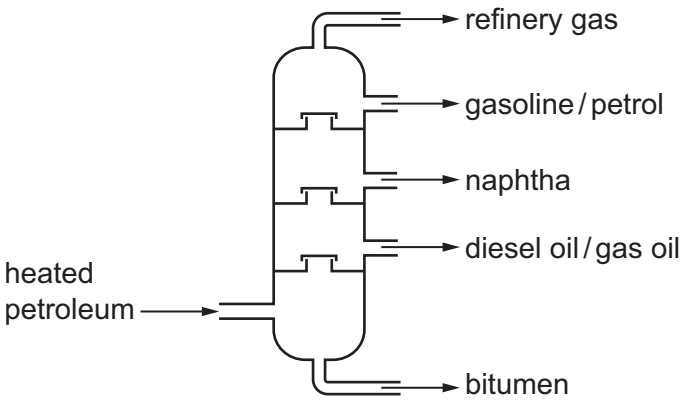


Figure 8.2

Ethane is obtained from the refinery gas fraction.

(i) Describe how the **chain length** of the fractions changes from the bottom to the top of the fractionating column.

..... [1]

(ii) State **one** use for the naphtha fraction.

..... [1]

[Total: 8]

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9 **(a)** State the difference between speed and velocity.

.....

.....

..... [2]

(b) Figure 9.1 shows a velocity–time graph for a toy car.

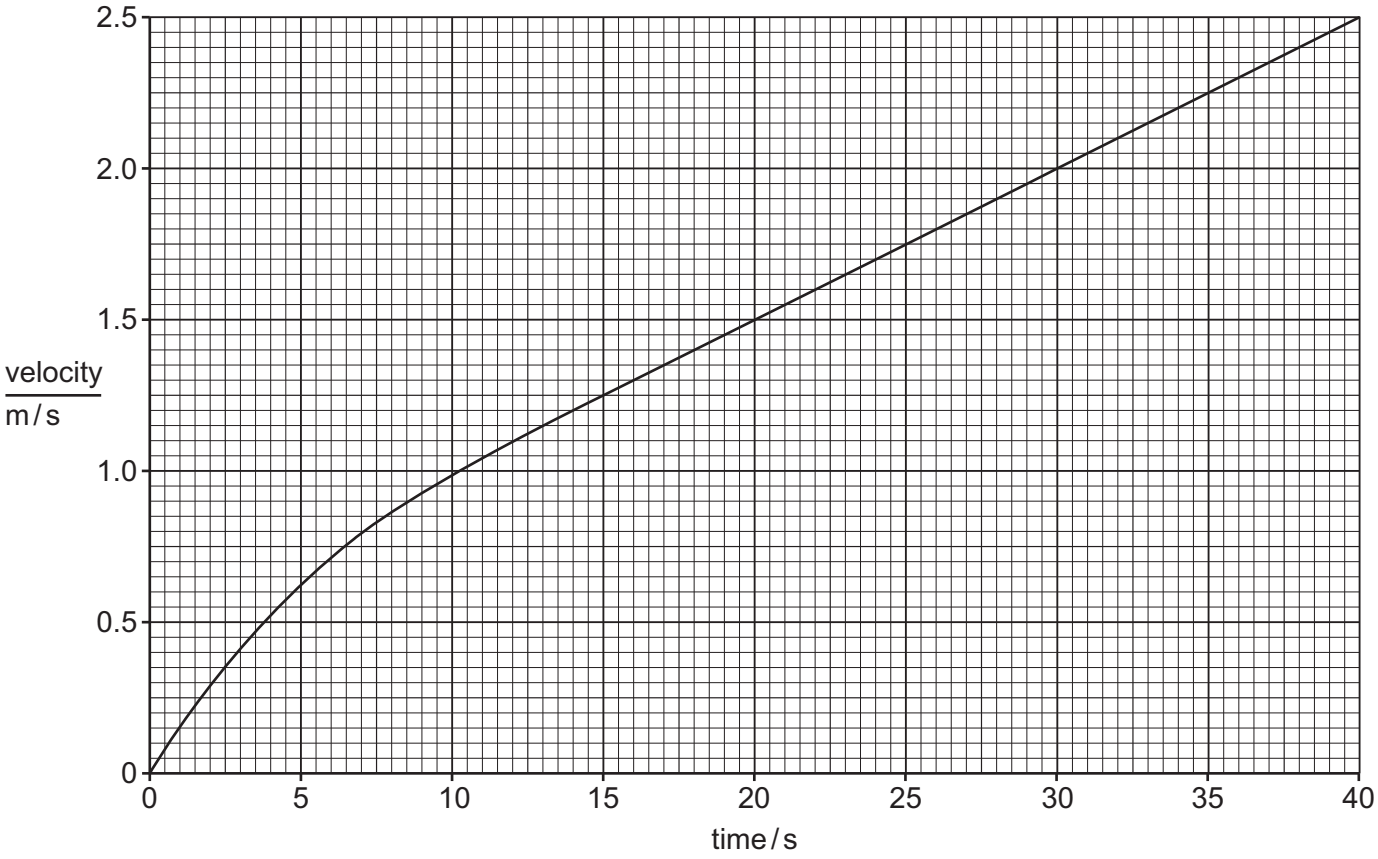


Figure 9.1

(i) Describe the motion of the car between 0 and 10 seconds.

.....

..... [1]

(ii) Calculate the acceleration of the car between 15 and 30 seconds.

acceleration = ... m/s^2 [2]

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(c) During part of another journey, the acceleration of the car is $5.0\,m/s^2$.

The mass of the car is 1.2 kg.

The driving force supplied by the car is 10.5 N.

(i) Calculate the magnitude of the friction forces acting on the car.

friction forces = ... N [3]

(ii) When the car reaches maximum velocity, its kinetic energy is 2.2 J.

Calculate the maximum velocity of the car.

maximum velocity = ... m/s [2]

[Total: 10]

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10 (a) (i) State **one** use of ultraviolet radiation.

..... [1]

(ii) State **one** harmful effect of ultraviolet radiation.

..... [1]

(b) (i) Complete the sentence to describe a longitudinal wave.

In a longitudinal wave, the direction of .....

is ..... to the direction of propagation.

[2]

(ii) Ultrasound is a longitudinal wave.

State the lowest frequency of ultrasound and include the unit.

..... [1]

(iii) A longitudinal wave has compressions and rarefactions.

State and explain the difference in pressure between compressions and rarefactions.

.....

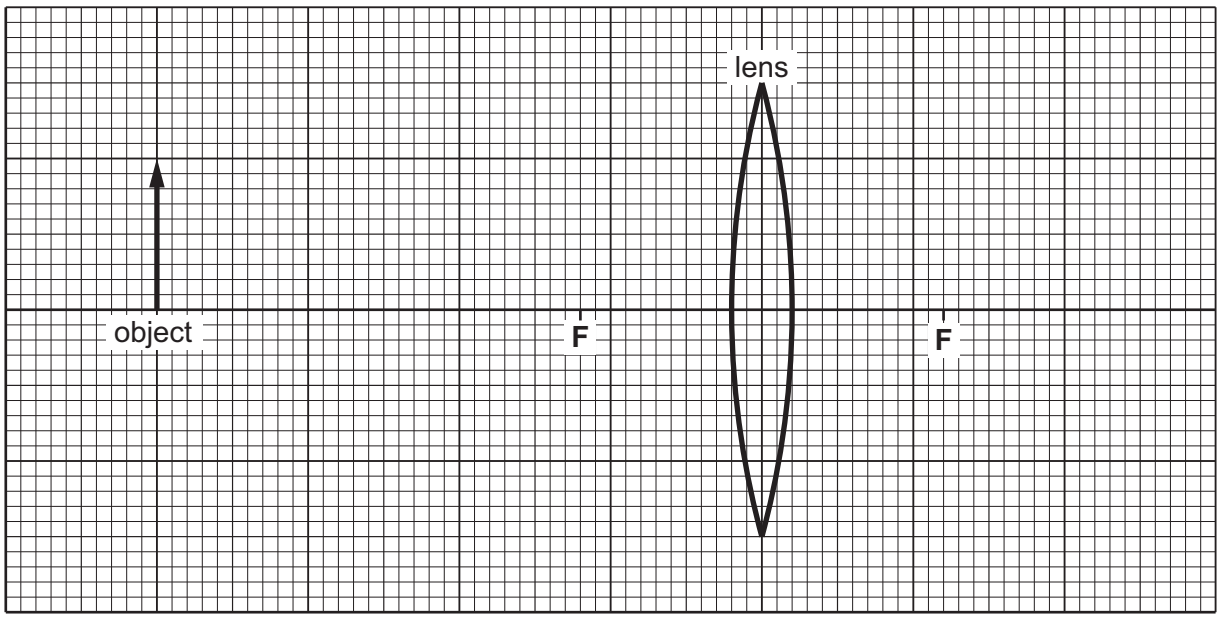
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..... [2]

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(c) Complete the ray diagram in Figure 10.1 to find the location of the image formed by the thin converging lens.

Mark the location of the image with an arrow.



F = principal focus

Figure 10.1

[3]

[Total: 10]

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11 (a) (i) State the change in the resistance of a metal wire when the length of the wire doubles.

.....

..... [1]

(ii) Wire **A** has a length of 45 m and a resistance of 12.6 Ω.

Wire **B** is made of the same metal as wire **A** and has a length of 45 m.

Wire **B** has twice the cross-sectional area of wire **A**.

Determine the resistance of wire **B**.

resistance of wire **B** = ... Ω [1]

(b) A 3.6 V cell is connected across three resistors as shown in Figure 11.1.

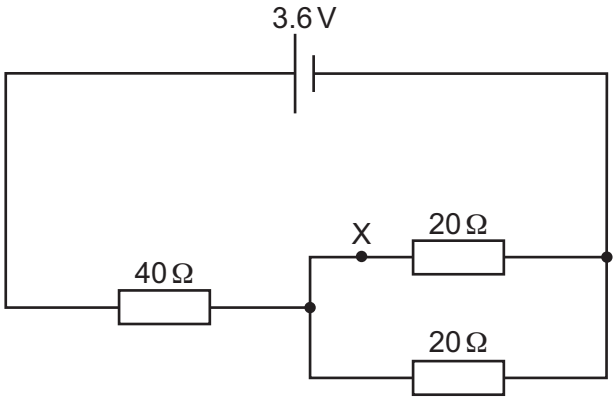


Figure 11.1

(i) Calculate the total resistance of the circuit.

total resistance = ... Ω [3]

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(ii) Calculate the current at point **X** in the circuit.

Use your answer to **11(b)(i)**.

current = ...A [2]

(c) In another circuit, a 3.6 V cell is connected across a single resistor.

The current in the circuit is 0.18 A.

Calculate the energy supplied by the cell in 1 minute.

energy = ... J [2]

[Total: 9]

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12 **(a)** The nuclide notation for a uranium isotope is $^{235}_{92}U$.

(i) State the number of protons and number of neutrons in a nucleus of this isotope.

number of protons = ...

number of neutrons = ...

[1]

(ii) State the relative charge on a nucleus of this isotope.

..... [1]

(iii) This isotope undergoes nuclear fission.

Describe the process of nuclear fission.

.....

..... [1]

(b) State a significant source of background radiation from outside Earth.

..... [1]

(c) Describe the most common nuclear reaction which occurs in the Sun.

.....

.....

..... [2]

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(d) The Moon orbits the Earth in a circular orbit once every 27 days.

The Moon travels at an orbital speed of 1030 m / s.

The speed of light in a vacuum is 3.0×10^8 m / s.

Calculate the time taken for a radio wave to travel from the Moon to the Earth.

time = ... s [3]

(e) The Big Bang Theory is supported by many astronomical observations.

State the Big Bang Theory.

.....

.....

.....

..... [2]

[Total: 11]

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The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 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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