



# Cambridge IGCSE™

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**COMBINED SCIENCE**

**0653/41**

Paper 4 Theory (Extended)

**May/June 2022**

**1 hour 15 minutes**

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 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 80.
- 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 **20** pages. Any blank pages are indicated.

1 (a) Fig. 1.1 is a diagram of the gas exchange system in humans.

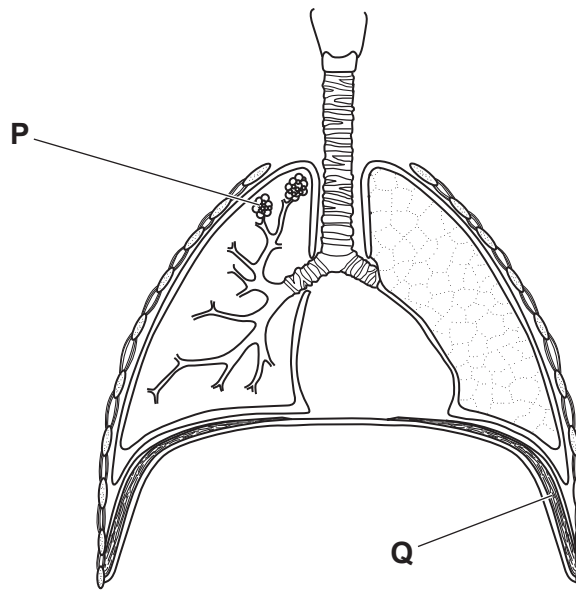


Fig. 1.1

(i) Identify the part labelled **P** in Fig. 1.1.  
Circle the correct answer.

- alveoli      diaphragm      intercostal muscle      larynx      trachea

[1]

(ii) Identify the part labelled **Q** in Fig. 1.1.  
Circle the correct answer.

- alveoli      diaphragm      intercostal muscle      larynx      trachea

[1]

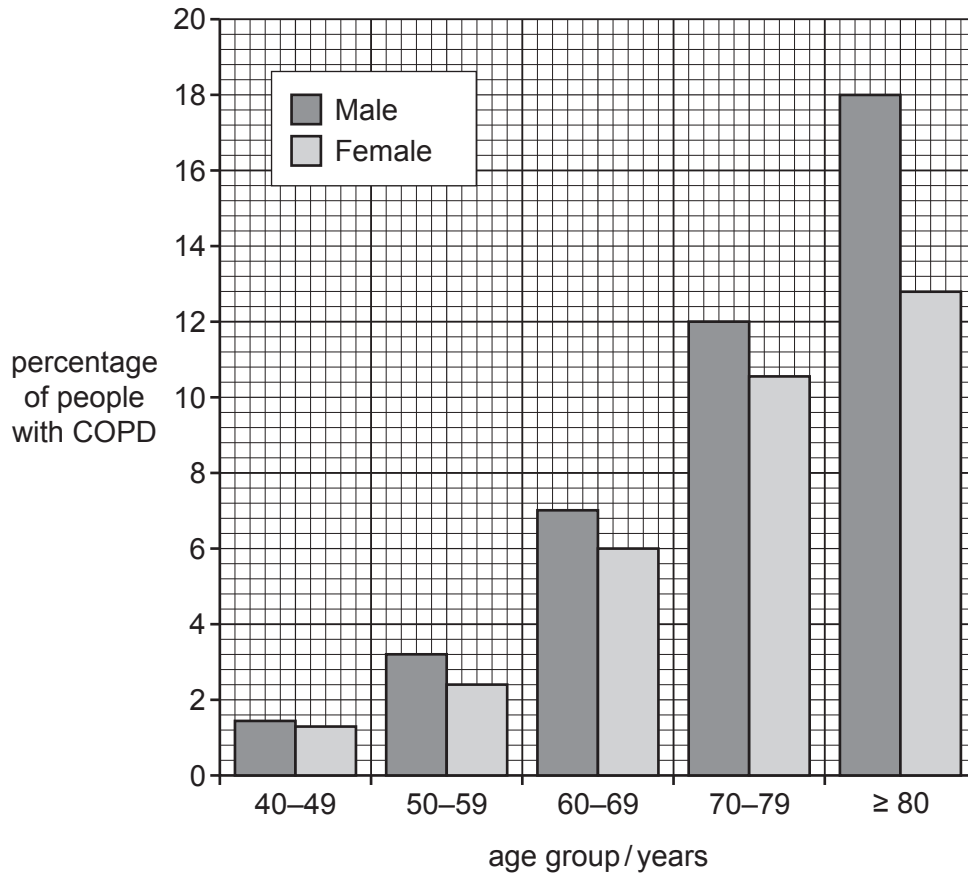
(iii) Tobacco smoke contains carbon monoxide.  
Carbon monoxide binds to haemoglobin.  
Explain how this affects respiration in the body.

.....  
.....  
..... [2]

(iv) Goblet cells are found in the tissue of the gas exchange system.  
Explain how goblet cells protect the gas exchange system from particles in the air.

.....  
.....  
..... [2]

(b) Fig. 1.2 shows some data on chronic obstructive pulmonary disorder (COPD) in people of different age groups.



**Fig. 1.2**

(i) Identify the percentage of females aged 60–69 with COPD in Fig. 1.2.

..... % [1]

(ii) Describe **two** trends shown in Fig. 1.2.

1 .....

.....

2 .....

.....

[2]

[Total: 9]

2 The outer shell electrons in atoms of elements **X**, **Y** and **Z** are shown in Fig. 2.1.

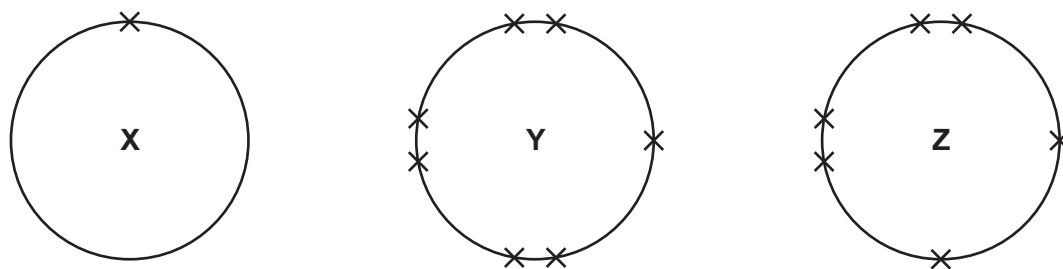


Fig. 2.1

(a) State the group of the Periodic Table in which element **Y** is placed.

group .....

[1]

(b) State the charge on the ion formed from an atom of element **Z**.

Explain your answer.

charge .....

explanation .....

.....

.....

[2]

(c) Table 2.1 shows some information about substances which contain the elements **X**, **Y** and **Z**.

Table 2.1

substance	bonding	structure	element or compound
<b>X<sub>2</sub>Z</b>	covalent	simple molecules	
<b>X<sub>2</sub></b>	covalent	simple molecules	
<b>Z<sub>2</sub></b>	covalent	simple molecules	

(i) Complete Table 2.1 to show whether each substance is an element or a compound. [1]

(ii) Draw a dot-and-cross diagram to show the outer shell electrons in a molecule of  $Z_2$ .

[2]

(iii) A student thinks that element **X** is lithium.

Use the information in Table 2.1 to explain why element **X cannot** be lithium.

.....  
..... [1]

(iv) Identify element **X**.

..... [1]

[Total: 8]

3 Fig. 3.1 shows a man pushing a shopping trolley forwards along a level surface.



Fig. 3.1

(a) Fig. 3.2 shows three of the forces acting on the trolley as the man pushes it.

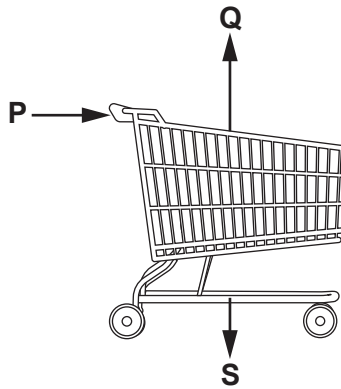


Fig. 3.2

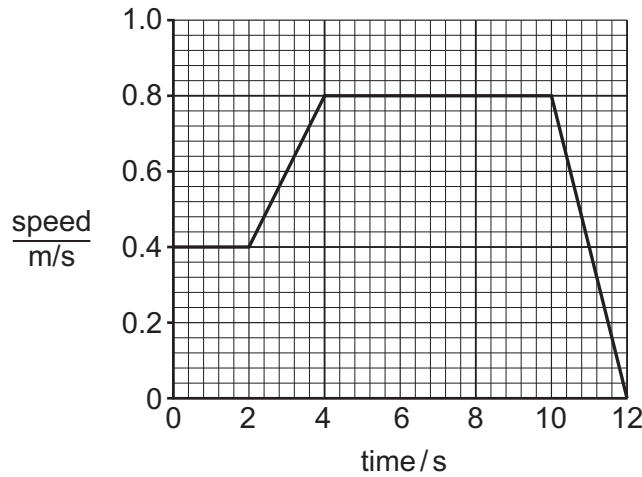
(i) Draw an arrow on Fig. 3.2 to show the direction of the friction force acting on the trolley.  
Label this force **R**. [1]

(ii) The trolley has a mass of 15 kg.  
The gravitational force on unit mass is 10 N/kg.  
Calculate the magnitude of force **S**.

force **S** = ..... N [1]

(iii) State the magnitude of force **Q**.  
Explain your answer.  
force **Q** = ..... N  
explanation ..... [1]

(b) Fig. 3.3 shows a speed–time graph of the motion of the trolley.



**Fig. 3.3**

(i) Use Fig. 3.3 to calculate the kinetic energy of the trolley at  $t = 1.0$  s.

The trolley has a mass of 15 kg.

kinetic energy = ..... J [3]

(ii) Use Fig. 3.3 to calculate the acceleration of the trolley between 2.0 s and 4.0 s.

Give the units of your answer.

acceleration = ..... units ..... [3]

(iii) Between 4.0 s and 10.0 s, the man pushes the trolley with a constant force of 25 N.

Calculate the work done by the man on the trolley between 4.0 s and 10.0 s.

work done = ..... J [3]

[Total: 12]

**[Turn over**

4 (a) Fig. 4.1 is a diagram of a wind-pollinated flower.

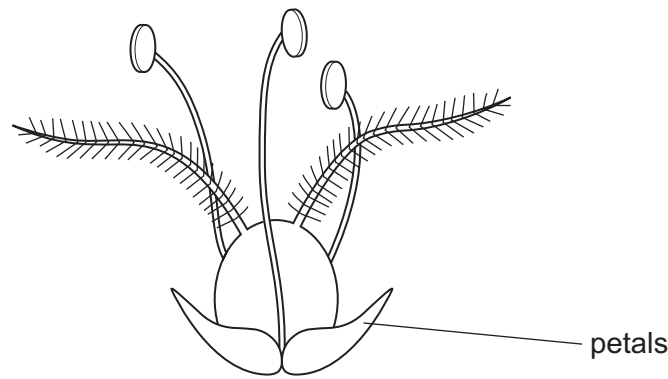


Fig. 4.1

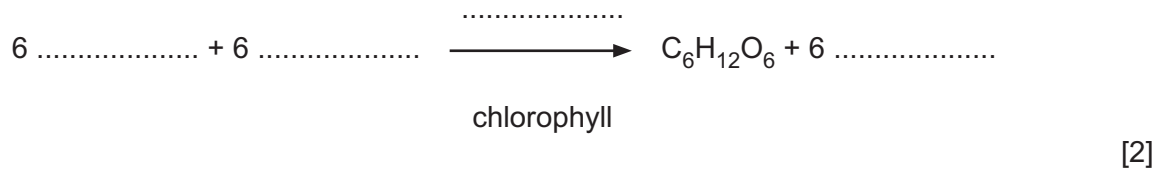
(i) Draw a label line on Fig. 4.1 to identify the part where fertilisation takes place. Label the line **F**. [1]

(ii) State **two** pieces of evidence from Fig. 4.1 that show this flower is a wind-pollinated flower.

- 1 .....
- 2 ..... [2]

(b) Plants synthesise carbohydrates by the process of photosynthesis.

(i) Complete the balanced equation for photosynthesis.



(ii) Explain the role of chlorophyll in the synthesis of carbohydrates.  
 .....  
 .....  
 ..... [2]



(c) Fig. 4.2 shows how transpiration rate and temperature change during the day.

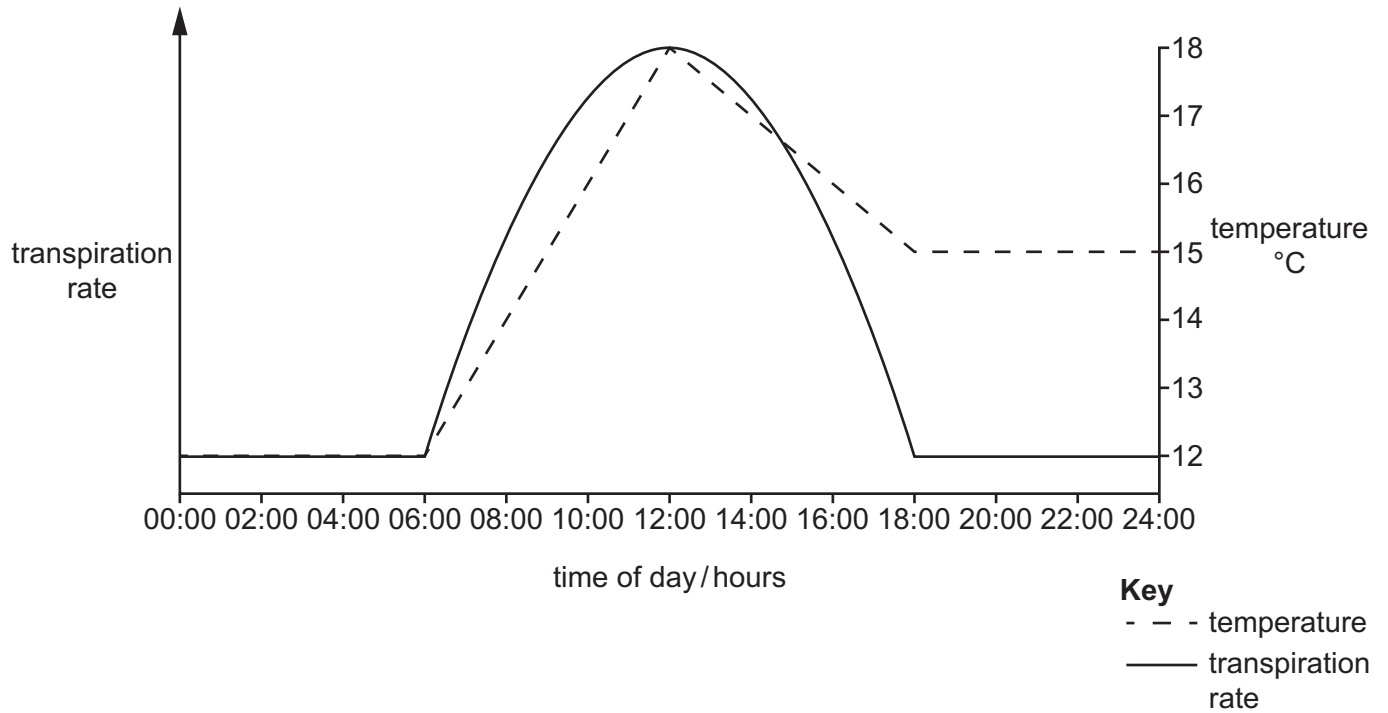


Fig. 4.2

Explain the effect of temperature on changes to transpiration rate between 12:00 and 18:00 hours in Fig. 4.2.

.....  
.....  
.....  
.....  
..... [3]

(d) Water is lost through stomata.

Explain why stomata are important for photosynthesis.

.....  
.....  
..... [2]

[Total: 12]

- 5 (a) A pH meter is an instrument which measures pH. The tip of the meter is dipped into a solution. The pH of the solution is displayed on a small screen as shown in Fig. 5.1.

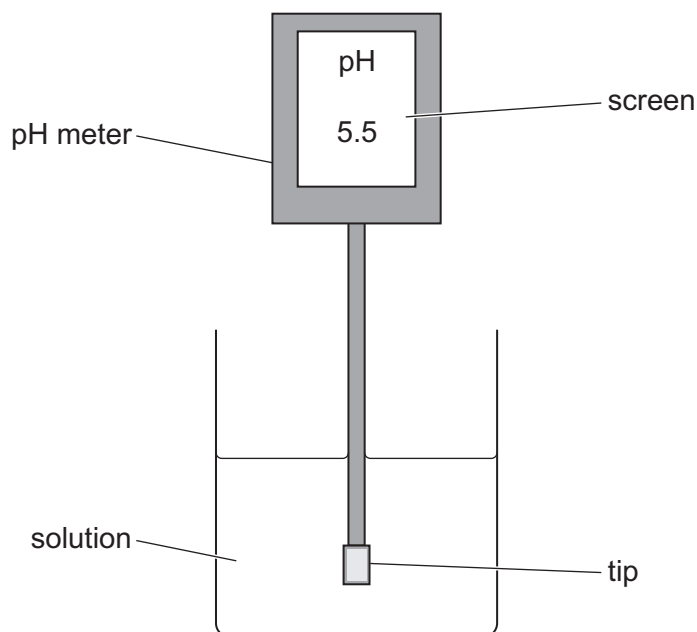


Fig. 5.1

The pH values of some aqueous solutions are measured using universal indicator paper and using a pH meter.

The results are shown in Table 5.1.

Table 5.1

aqueous solution	pH value measured using universal indicator paper	pH value measured using a pH meter
ammonia	12	11.6
ammonium nitrate	5	5.3
ammonium sulfate	5	5.5
sulfuric acid	1	0.5
nitric acid	1	0.5

- (i) Describe the procedure used to measure the pH of a solution using universal indicator paper.

.....

.....

..... [2]

- (ii) Suggest **two** advantages of using a pH meter rather than universal indicator paper to test the pH of some solutions.

Use Fig. 5.1 and Table 5.1 to help you.

1 .....

.....

2 .....

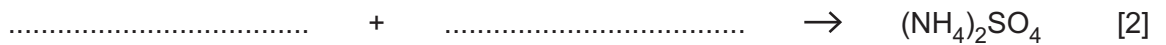
.....

[2]

- (b) Farmers use solid ammonium nitrate and solid ammonium sulfate to improve the growth of crops.

- (i) Aqueous ammonia and dilute sulfuric acid react to make aqueous ammonium sulfate.

Complete the balanced equation for this reaction.



- (ii) Suggest the name of the compound that reacts with aqueous ammonia to form ammonium nitrate.

..... [1]

- (iii) Describe how solid ammonium sulfate is obtained from aqueous ammonium sulfate.

.....

.....

..... [2]

[Total: 9]

6 (a) The Earth is heated by infrared radiation from the Sun.

(i) State the speed at which the infrared radiation travels from the Sun to the Earth.

..... [1]

(ii) The infrared radiation takes 8 min 20s to travel from the Sun to the Earth.

Use your answer to (a)(i) to calculate the distance in kilometres of the Earth from the Sun.

distance = ..... km [3]

(iii) Fig. 6.1 shows an incomplete electromagnetic spectrum.

On Fig. 6.1, write infrared radiation in its correct place.

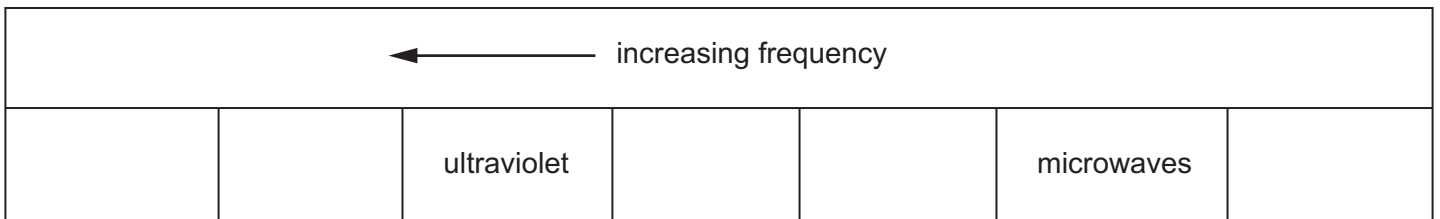
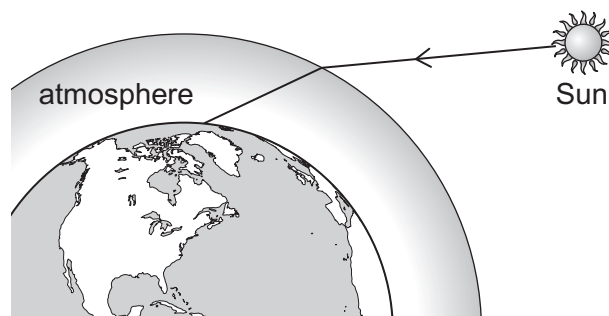


Fig. 6.1

[1]

(b) (i) Fig. 6.2 shows how an infrared ray from the Sun is refracted as it enters the Earth's atmosphere.



not to scale

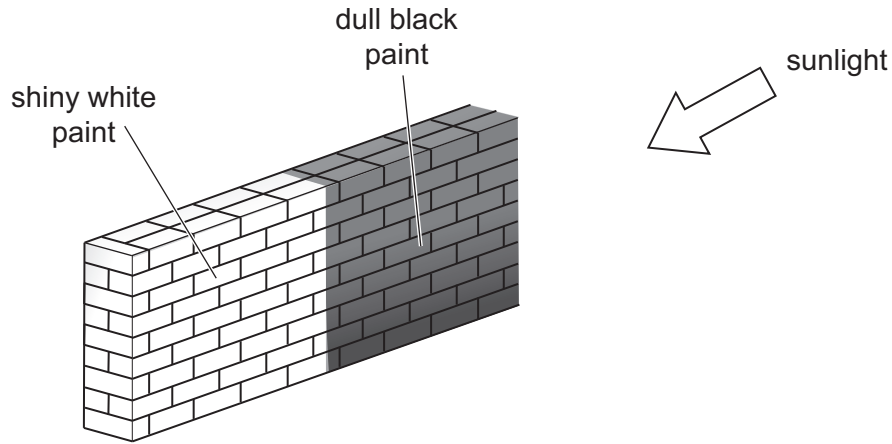
Fig. 6.2

Explain why the ray is refracted as it moves from space into the Earth's atmosphere.

.....  
 ..... [1]

(ii) Fig. 6.3 shows sunlight shining on a brick wall.

One half of the wall is painted shiny white and the other half is painted dull black.



**Fig. 6.3**

Explain why the temperature of the bricks painted dull black increases faster than the temperature of the bricks painted shiny white.

.....

.....

..... [2]

[Total: 8]

7 (a) Fig. 7.1 shows part of the human alimentary canal and associated organs.

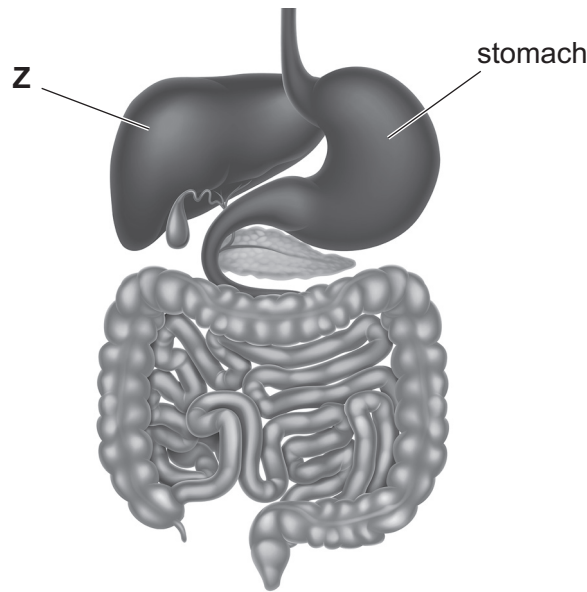


Fig. 7.1

(i) Identify the part labelled Z in Fig. 7.1.

..... [1]

(ii) Complete this definition of chemical digestion.

Chemical digestion is the breakdown of large ..... molecules into smaller ..... molecules.

[1]

(b) Amylase and lipase are found in the alimentary canal.

Compare the similarities and differences between the functions of amylase and lipase.

similarities .....

.....

differences .....

.....

[3]

(c) Digested nutrients move out of the alimentary canal into the blood stream.

State the component of blood that transports digested nutrients.

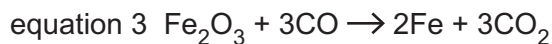
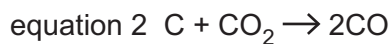
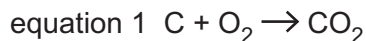
..... [1]

[Total: 6]

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- 8 (a) Iron is extracted from hematite in a blast furnace.

Equations for three reactions that take place in the blast furnace are listed.



- (i) State which equation, 1, 2 or 3, represents a reaction in which a carbon compound acts as a reducing agent.

Explain your answer.

equation .....

explanation .....

..... [1]

- (ii) Name **two** gases that are produced in these equations and describe a health or environmental problem caused by each.

gas 1 .....

problem .....

.....

gas 2 .....

problem .....

..... [3]

- (iii)  $Fe_2O_3$  contains oxide ions,  $O^{2-}$ .

State the charge on each iron ion in  $Fe_2O_3$ .

..... [1]



(b) Table 8.1 lists the method of extraction of iron and some other metals from their ores.

**Table 8.1**

metal	method of extraction
iron	heating with carbon
aluminium	electrolysis
sodium	electrolysis
zinc	heating with carbon

(i) Identify the metal in Table 8.1 that has the greatest tendency to form positive ions.

Give a reason for your answer.

metal .....

reason .....

.....

[1]

(ii) Copper and magnesium are also extracted from their ores.

Suggest a method of extraction for copper and for magnesium from their ores.

Give reasons for your answers.

Use information from Table 8.1 and your knowledge of the reactivity series to help you.

copper method of extraction .....

reason .....

.....

magnesium method of extraction .....

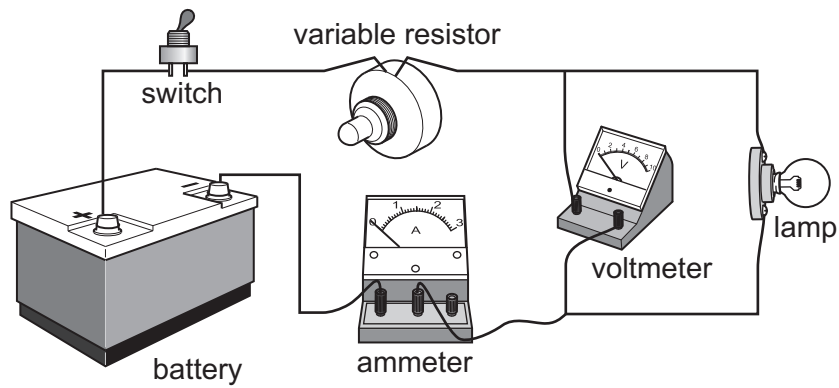
reason .....

.....

[3]

[Total: 9]

9 Fig. 9.1 shows an electric circuit.



**Fig. 9.1**

(a) The switch is turned on, and the variable resistor adjusted until the voltmeter reading is 6.0V. The ammeter reading is 0.75A.

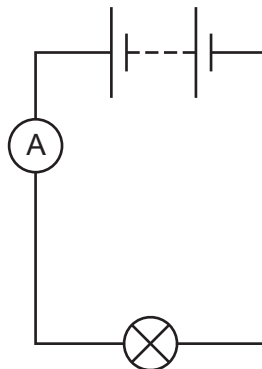
(i) Calculate the resistance of the lamp.

resistance = .....  $\Omega$  [2]

(ii) Calculate the power of the lamp.

power = ..... W [2]

(b) On Fig. 9.2, complete the circuit diagram for the circuit shown in Fig. 9.1.



**Fig. 9.2**

[3]

[Total: 7]

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The Periodic Table of Elements

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

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

lanthanoids

actinoids

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