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CO-ORDINATED SCIENCES

0654/41

Paper 4 Theory (Extended)

May/June 2025

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 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.
- 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. Any blank pages are indicated.

- 1 (a) Carbon dioxide is taken in for the process of photosynthesis.

State the balanced symbol equation for photosynthesis.

..... [2]

- (b) Fig. 1.1 shows the net uptake and the net release of carbon dioxide by a plant between midnight and midday.

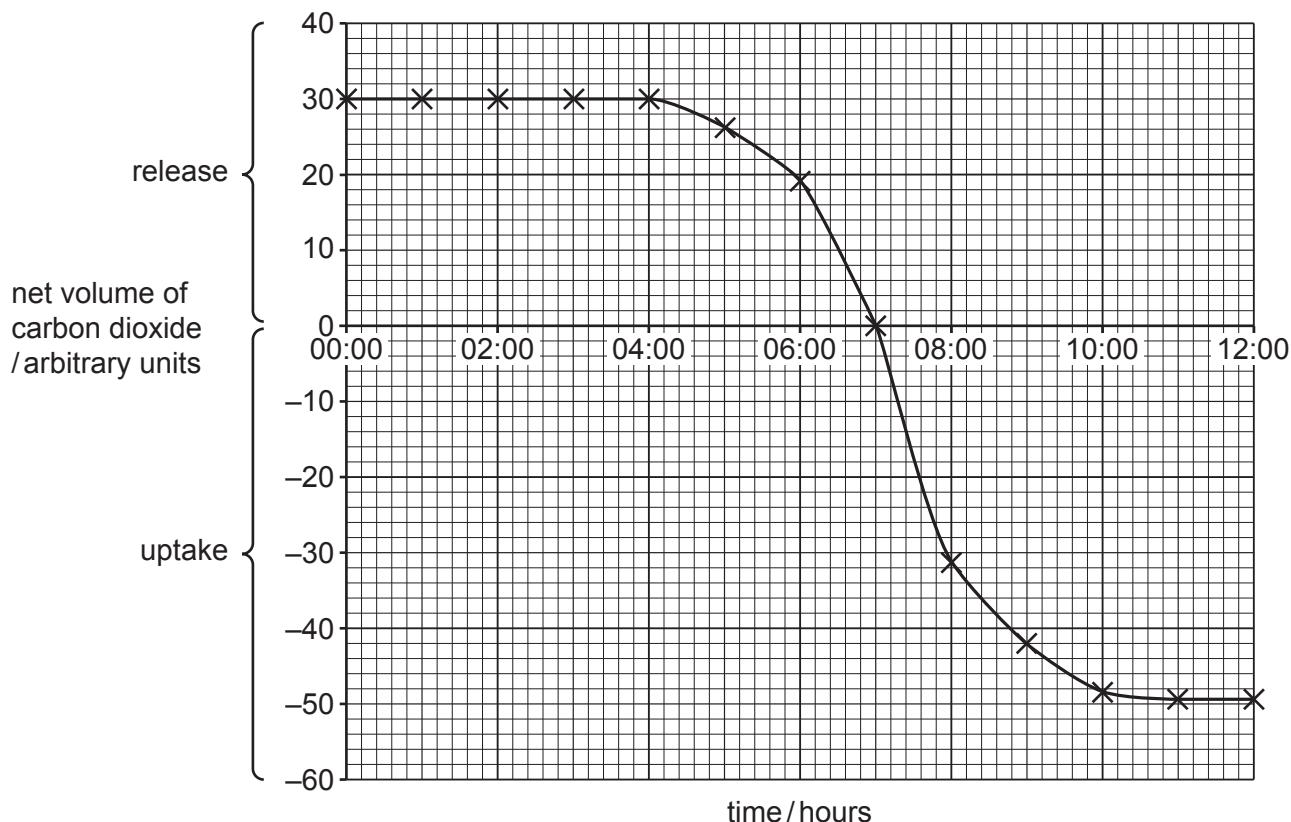


Fig. 1.1

Complete the sentences to explain the shape of the graph shown in Fig. 1.1.

The shape of the graph is linked to two processes: photosynthesis and process X.

At midnight (00:00 hours), the net volume of carbon dioxide is due to process X. Process X is

..... .

There is no photosynthesis at midnight because there is no energy available at night.

Between 05:00 – 10:00 hours, the rate of photosynthesis as energy becomes available during the day.

The rate of photosynthesis equals the rate of process X at hours.

[4]

- (c) The uptake and release of carbon dioxide by the same plant is measured on a different day. On this day, the temperature is lower than the previous day.

This time, the net volume of carbon dioxide uptake levels out at -40 arbitrary units.

Enzymes are required for photosynthesis.

Explain this difference in net volume of carbon dioxide uptake.

.....

.....

.....

.....

.....

[3]

[Total: 9]

- 2 Fig. 2.1 is a diagram of the human heart and the blood vessels that connect with it.

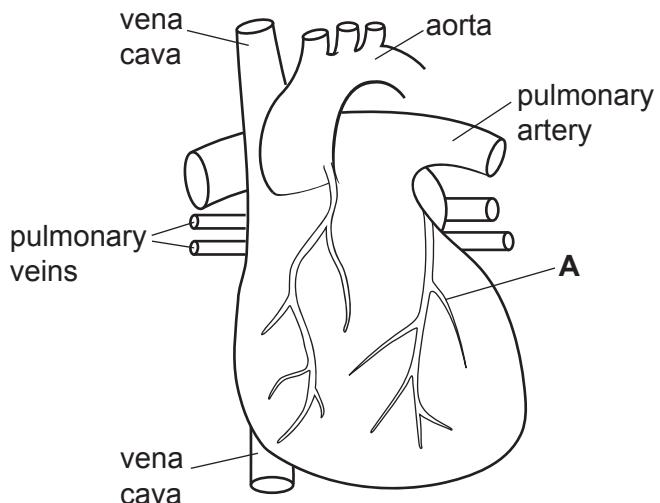


Fig. 2.1

- (a) Describe **two** differences between the pulmonary artery and the vena cava.

1

.....

2

.....

[2]

- (b) Describe how blood is moved through the heart from the pulmonary veins to the aorta.

Include the names of the chambers.

.....

.....

.....

.....

.....

.....

.....

[4]

(c) A patient has a problem with his heart.

(i) The doctor takes the patient's pulse rate.

State **one** other way doctors monitor the activity of the heart.

..... [1]

(ii) The doctor thinks the blood vessel labelled **A** in Fig. 2.1 is blocked.

Explain why this causes a problem with the function of the heart.

Include the name of blood vessel **A** in your answer.

.....
.....
.....
.....
.....

[3]

[Total: 10]

- 3 Fig. 3.1 is a magnified image of a plant root tip viewed using a light microscope.

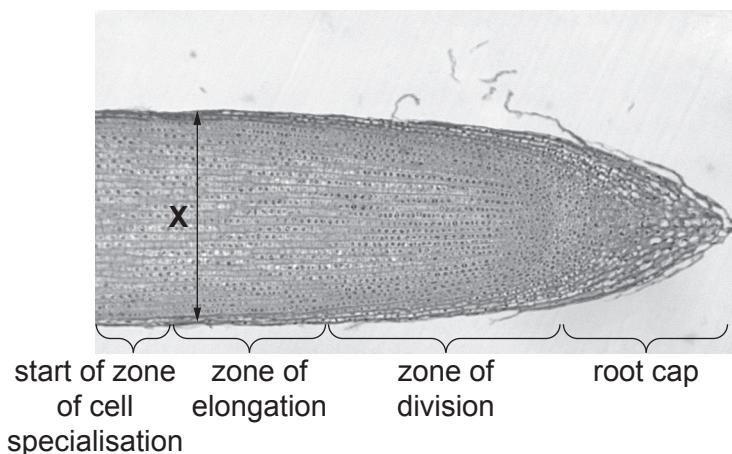


Fig. 3.1

- (a) At X in Fig. 3.1, there are 37 cells across the width of the root tip.

The actual width of the root tip at X is 1.2 mm.

Calculate the average size of the cells in the root tip in μm .

..... μm [2]

- (b) Fig. 3.1 shows a zone in the root tip where cells become specialised.

Tick (\checkmark) one box to identify a type of specialised cell made in the root.

ciliated cells

guard cells

palisade mesophyll cells

phloem cells

[1]

(c) Fig. 3.1 shows a zone in the root tip where cells divide so the root can grow.

(i) State the type of cell division needed for growth.

..... [1]

(ii) During this type of cell division, the number of chromosomes is maintained in each daughter cell.

Describe **two** processes in cell division that ensure that the chromosome number is maintained.

1

.....

2

.....

[2]

- (d) A different type of cell division takes place in the ovary and anther of flowers to make gametes.
- (i) Fig. 3.2 is a diagram of a wind-pollinated flower.

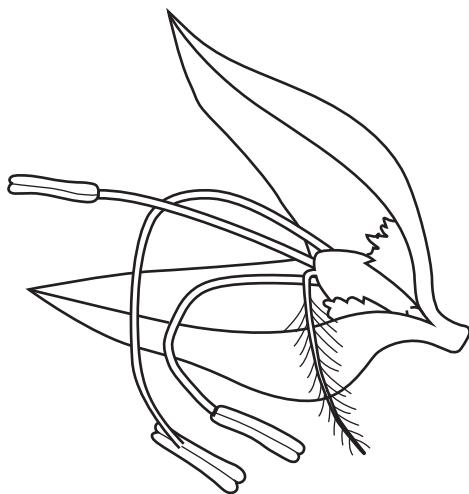


Fig. 3.2

On Fig. 3.2, draw a label line and the letter **A** to identify **one** anther.

[1]

- (ii) The anthers produce male gametes.

Complete the sentences about male gametes in plants.

Male gametes in plants are called grains.

During production of male gametes, the chromosome number is halved from to haploid.

Male gametes produced are all genetically

A nucleus of a male gamete will fuse with the nucleus of an ovule. This process is called

[4]

- (iii) Describe **one** advantage of sexual reproduction to a population of plants in the wild.

.....
.....

[1]

[Total: 12]

- 4 Tropical forests are some of the most important ecosystems in the world.

- (a) Fig. 4.1 is a food chain from a tropical forest.

organism: banana tree → grasshopper → frog → python

position in food chain: producer

Fig. 4.1

Complete Fig. 4.1 to show the position of each organism in this food chain.

[2]

- (b) Fig. 4.2 shows another food chain that includes the python.

banana tree → monkey → python

Fig. 4.2

Explain why it is more efficient for the python to eat a monkey and **not** a frog.

Include trophic levels in your answer.

.....
.....
.....
.....
.....

[3]

- (c) The Amazon rainforest is a large tropical forest.

In 1970, the Amazon rainforest covered an area of 4.1 million km².

By 2022, the area covered was estimated to be 3.3 million km².

One effect of this deforestation is a loss in biodiversity.

Explain **other** negative effects that deforestation has on the environment.

[Total: 9]

- 5 Water exists in the solid, liquid or gas state.

The particles are arranged differently in each physical state.

- (a) Name the state where the water particles are furthest apart.

..... [1]

- (b) Describe what happens to the **movement** of water particles during melting.

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

- (c) A student takes some ice out of the freezer and leaves it in a beaker in a warm room.

Fig. 5.1 shows how the temperature in the beaker changes.

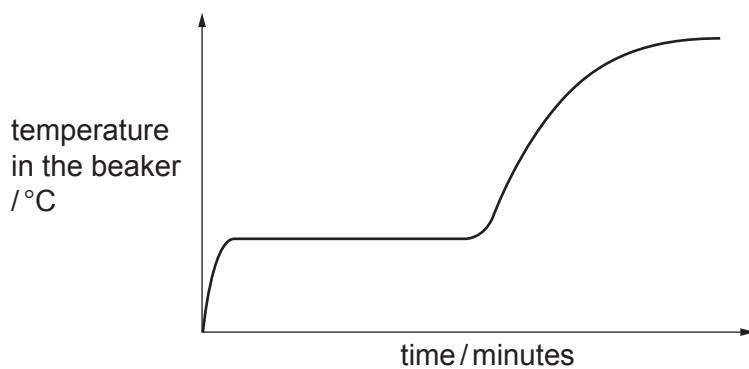


Fig. 5.1

- (i) Label the part of the graph where the ice is melting with the letter **X**. [1]

- (ii) Describe how Fig. 5.1 shows that the ice is pure rather than a mixture.

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

- (d) Domestic water is treated so that it is pure enough to drink.

Draw **one** line from each **treatment** to show **why it is used**.

treatment	why it is used
chlorination	to remove solids
sedimentation and filtration	to remove tastes and odours
use of carbon	to kill microbes

[2]

- (e) Water, H_2O , is a simple covalent molecule.

- (i) Complete the dot-and-cross diagram in Fig. 5.2 to show the bonding in water.

Only show the outer-shell electrons.

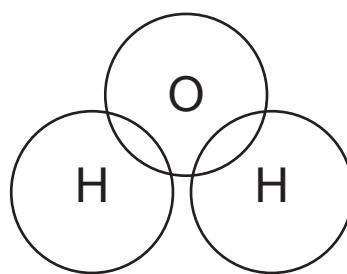


Fig. 5.2

[2]

- (ii) Explain why pure water is a poor conductor of electricity.

.....
.....

[1]

[Total: 10]

- 6 (a) A sodium atom is represented with numbers next to its chemical symbol, as shown in Fig. 6.1.



Fig. 6.1

Complete Table 6.1 to show the structure of a sodium atom.

Table 6.1

atomic number	mass number	number of		
		protons	neutrons	electrons
.....	23	11

[2]

- (b) Fig. 6.2 shows an outline of the Periodic Table.

The letter **E** shows the position of an element in the Periodic Table.

The letter **E** is **not** the chemical symbol of the element.

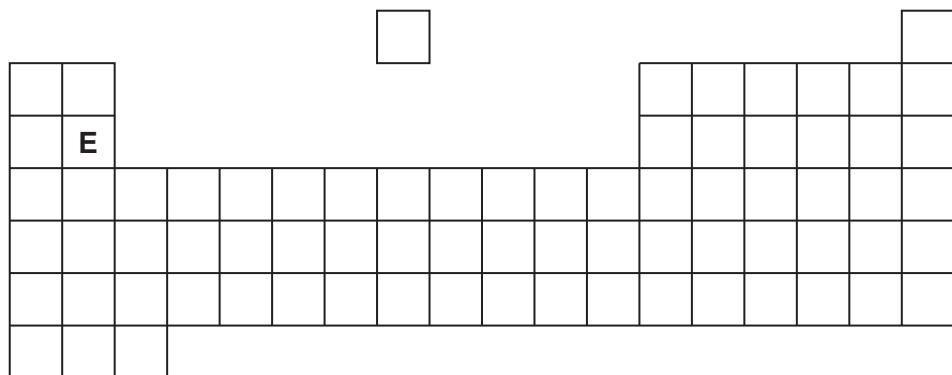


Fig. 6.2

Predict the electronic configuration of element **E**.

Tick (✓) **one** box.

- | | |
|-------|--------------------------|
| 2.2 | <input type="checkbox"/> |
| 2.8.2 | <input type="checkbox"/> |
| 2.3 | <input type="checkbox"/> |
| 2.8.3 | <input type="checkbox"/> |

[1]

- (c) Carbon-12 and carbon-13 are two isotopes of the element carbon.

These isotopes of carbon have the same chemical properties.

Explain why.

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

- (d) State the type of oxide formed when carbon, a non-metal, reacts with oxygen to produce carbon dioxide, CO_2 .

..... [1]

- (e) Carbon dioxide is a greenhouse gas and causes global warming.

Complete the sentences to describe how carbon dioxide causes global warming.

Use words from the list.

Each word can be used once, more than once, or not at all.

absorbed
reflected
refracted
stored

Energy from the Sun reaches the Earth's surface. Some energy is

..... back into space. Most of the energy is

..... by the Earth's surface, causing an increase in

temperature. The warm Earth emits energy. Some of this emitted energy is then

..... by greenhouse gases. When this energy is re-emitted, it

can be transferred back to the Earth's surface.

[3]

- (f) Some coal burns to make 11 000 g of carbon dioxide gas.

Calculate the volume occupied by 11 000 g of carbon dioxide gas.

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).

[A_r : C, 12; O, 16]

volume of carbon dioxide gas = dm³ [3]

[Total: 11]

- 7 The metal iron is extracted from hematite in a blast furnace.

The extraction happens in several stages.

- (a) In the first stage, carbon (coke) is burnt to provide heat and produce carbon dioxide.

State the type of reaction that transfers thermal (heat) energy to the surroundings.

..... [1]

- (b) In the second stage, carbon reacts with carbon dioxide to make carbon monoxide.



State what happens to the carbon dioxide in this reaction.

Choose from the list.

combustion

oxidation

reduction

thermal decomposition

..... [1]

- (c) In the third stage, iron(III) oxide, Fe_2O_3 , reacts with carbon monoxide.

Iron and carbon dioxide are made.

Construct the balanced symbol equation for this reaction.

..... [2]

- (d) Calcium carbonate (limestone) is added to the blast furnace to remove impurities from the hematite.

The calcium carbonate thermally decomposes to make calcium oxide and carbon dioxide.



Calculate the mass of calcium carbonate needed to make 7 tonnes of calcium oxide.

[A_r : C, 12; Ca, 40; O, 16]

$$\text{mass of calcium carbonate} = \dots \text{tonnes} \quad [2]$$

- (e) Iron is protected from rusting by coating the iron with a layer of zinc.

This is called sacrificial protection.

Explain how sacrificial protection protects iron.

Use ideas about the reactivity series and loss of electrons.

.....
.....
.....

[2]

- (f) Fig. 7.1 shows the metallic bonding in zinc.

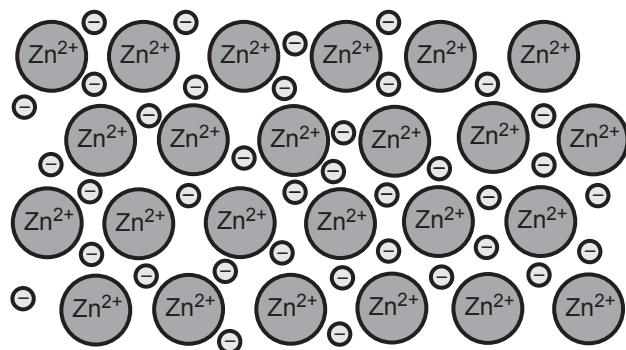


Fig. 7.1

Use Fig. 7.1 to describe the metallic bonding in zinc.

.....
.....
.....

[2]

[Total: 10]

[Turn over]

- 8 Petroleum is separated into useful fractions by fractional distillation.

Fig. 8.1 shows the fractions obtained.

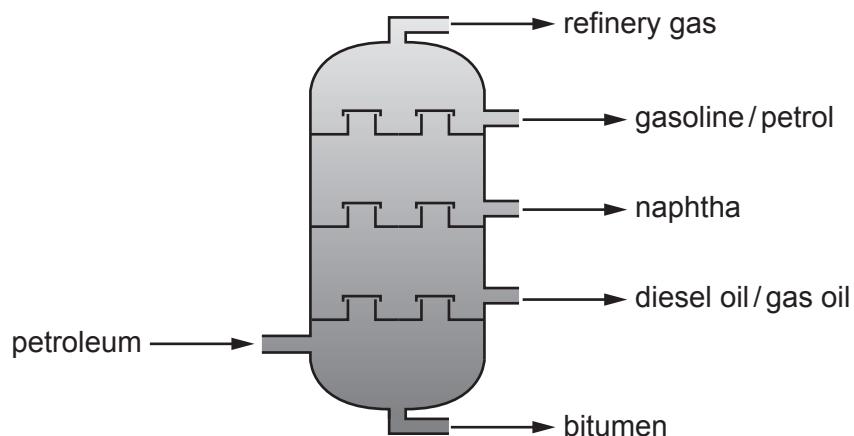


Fig. 8.1

- (a) Describe how the chain length and the boiling points of the fractions change from the bottom to the top of the fractionating column.

chain length

boiling points

[2]

- (b) (i) Describe how large alkane molecules produced by fractional distillation are changed into smaller alkene molecules.

..... [2]

(ii) The large alkane $C_{22}H_{46}$ is changed into butane and an alkene.

Complete the balanced symbol equation for this reaction.



[2]

(c) A mixture containing 5.6 g of ethene, C_2H_4 , is allowed to react with 5.4 g of steam.

Ethanol, $\text{C}_2\text{H}_5\text{OH}$, is made.



Determine the limiting reactant in this reaction.

Show your working.

[A_r : C, 12; H, 1; O, 16]

[3]

[Total: 9]

9 (a) The Sun is the star in our Solar System.

(i) State the **two** most common elements found in the Sun.

1

2

[2]

(ii) Describe how the following change, if at all, when the distance from the Sun increases:

the strength of the Sun's gravitational field

.....

the orbital speed of the planets.

.....

[2]

(b) The Earth is 1.5×10^{11} m from the Sun.

The Earth takes one year to complete an orbit of the Sun.

Calculate the orbital speed of the Earth around the Sun.

orbital speed = m/s [3]

(c) State, in order, the stages in the life cycle of a very large mass star after it leaves the stable main sequence stage.

1

2

3

[3]

- (d)** Describe the difference between the processes of nuclear fusion and nuclear fission.

.....

.....

.....

[2]

[Total: 12]

- 10 (a) A rocket travels vertically upwards.

Fig. 10.1 shows the speed–time graph for the rocket.

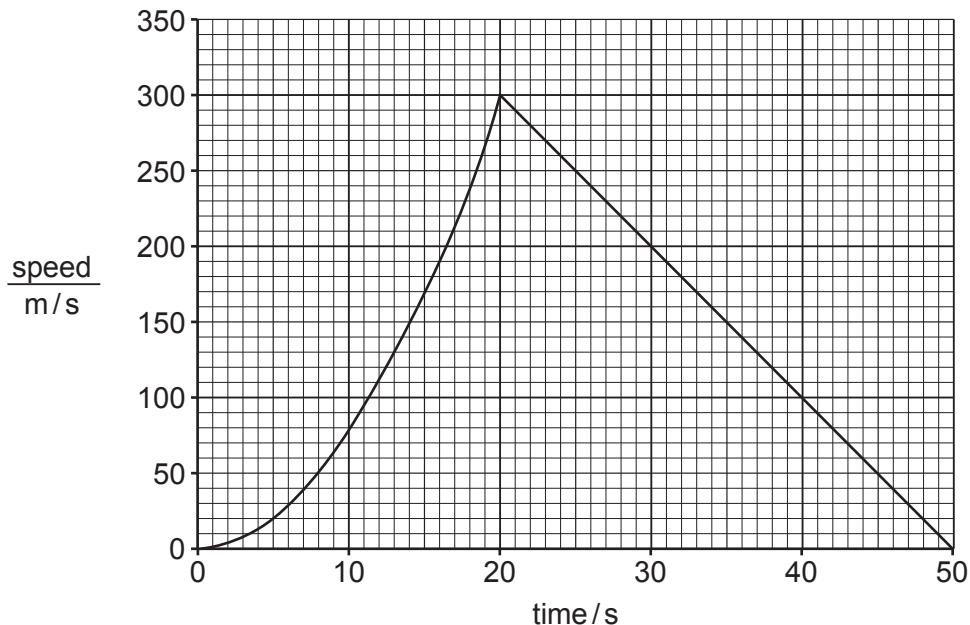


Fig. 10.1

- (i) Describe the motion of the rocket in the first 20 seconds.

..... [1]

- (ii) Calculate the deceleration of the rocket between time = 20 s and time = 50 s.

State the unit of your answer.

deceleration = unit [3]

- (iii) Calculate the distance travelled by the rocket between time = 30 s and time = 50 s.

distance = m [2]

(iv) State the time at which the rocket reaches its maximum height above the ground.

time = s [1]

(b) A car travels at constant speed on a horizontal road.

State and describe the horizontal forces acting on the car.

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

[Total: 9]

- 11 (a) (i) Describe **one** similarity and **two** differences between boiling and evaporation.

similarity

.....
difference 1

.....
difference 2

[3]

- (ii) State **three** factors which increase the rate of evaporation.

1

2

3

[3]

- (b) Fig. 11.1 shows a beaker of water on a tripod and gauze.

The beaker of water is being heated.

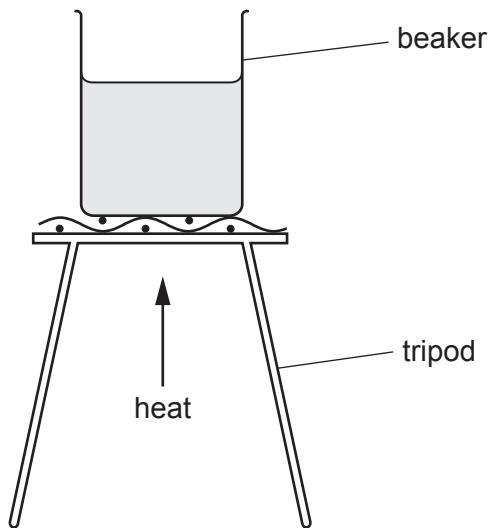


Fig. 11.1

Water at the bottom of the beaker is heated by conduction through the glass beaker.

Explain the process of **convection** which causes all the water in the beaker to increase in temperature.

.....

.....

.....

.....

.....

[3]

[Total: 9]

- 12 (a) Fig. 12.1 shows a 10Ω resistor and a resistor \mathbf{R} of unknown resistance connected in parallel with a 1.8 V cell.

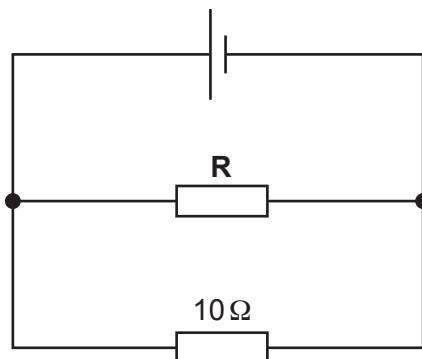


Fig. 12.1

The current in the cell is 0.32A.

The current in the 10Ω resistor is 0.18A.

- (i) Calculate the current in resistor \mathbf{R} .

$$\text{current} = \dots \text{A} \quad [1]$$

- (ii) State the potential difference across resistor \mathbf{R} .

$$\text{potential difference} = \dots \text{V} \quad [1]$$

- (b) A 40Ω resistor and a 20Ω resistor are connected in parallel.

Calculate the combined resistance of the two resistors.

$$\text{resistance} = \dots \Omega \quad [2]$$

- (c) (i) A computer projector has a power rating of 750W.

Mains potential difference is 230V.

Calculate the electric current in the projector.

$$\text{current} = \dots \text{A} \quad [2]$$

- (ii) The computer projector uses a lens to form an image.

In another device, the object is placed between the principal focus and the lens.

On Fig. 12.2, draw rays to find the position of the image formed.

Use an arrow to represent the image.

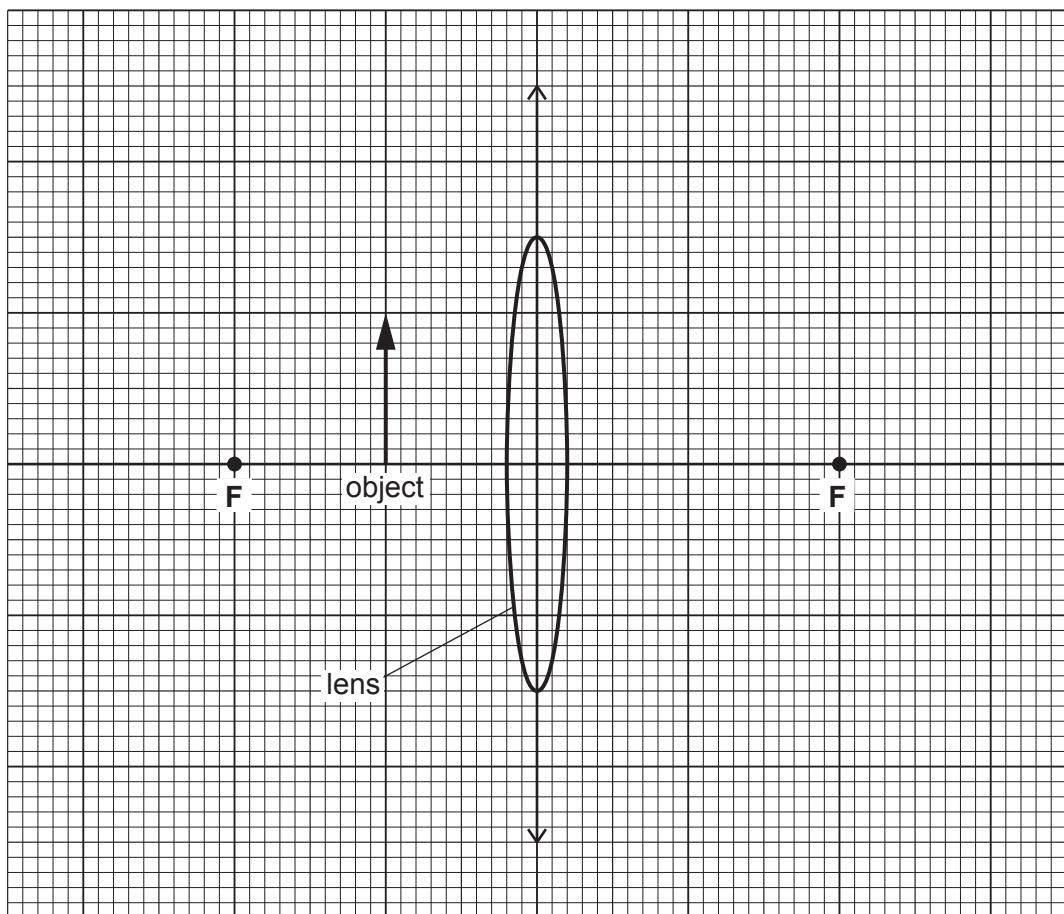


Fig. 12.2

[3]

- (iii) State a use of the arrangement shown in Fig. 12.2.

..... [1]

[Total: 10]

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The Periodic Table of Elements

Group		I				II				Key				III				IV				V				VI				VII																						
3	Li	4	Be	beryllium 9						1	H	hydrogen 1																2	He	helium 4																						
11	Na	12	Mg	magnesium 24																								10	Ne	neon 20																						
19	K	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	cobalt 56	27	Co	nickel 59	28	Ni	zinc 65	29	Cu	gallium 70	30	Zn	germanium 73	31	Ge	arsenic 75	32	As	selenium 79	33	Se	bromine 80	34	Br	iodine 84	35	Kr	krypton 84	36		
37	Rb	38	Sr	strontium 88	39	Zr	zirconium 91	40	Ti	niobium 93	41	Nb	molybdenum 96	42	Tc	technetium —	43	Ru	rutheonium 101	44	Pd	palladium 103	45	Ag	silver 108	46	Cd	cadmium 112	47	In	indium 115	48	Tl	thallium 119	49	Sn	tin 119	50	Sb	antimony 122	51	Te	tellurium 128	52	I	iodine 127	53	Xe	xenon 131	54		
55	Cs	56	Ba	barium 137	57-71	Hf	hafnium 178	72	Ta	tantalum 181	73	W	tungsten 184	74	Re	rhodium 186	75	Os	osmium 190	76	Ir	iridium 192	77	Pt	platinum 195	78	Hg	mercury 197	79	Tl	thallium 201	80	Pb	lead 204	81	Bi	bismuth 207	82	Po	polonium 209	83	At	astatine —	84	Rn	radon —	85					
87	Fr	88	Ra	radium —	89-103	Rf	actinoids —	104	Db	—	105	Ds	—	106	Bh	bohrium —	107	Mt	meltingium —	108	Rs	—	109	Ds	—	110	Rg	—	111	Nh	nilonium —	112	F1	florium —	113	Mc	moscovium —	114	Lv	livmorium —	115	Ts	tennessine —	116								

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