Cambridge Assessment International Education

Cambridge IGCSE™

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

8436842822

CO-ORDINATED SCIENCES **0654/42**

Paper 4 Theory (Extended) **February/March 2024**

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.

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)** Fig. 1.1 is a diagram of the male reproductive system in humans.

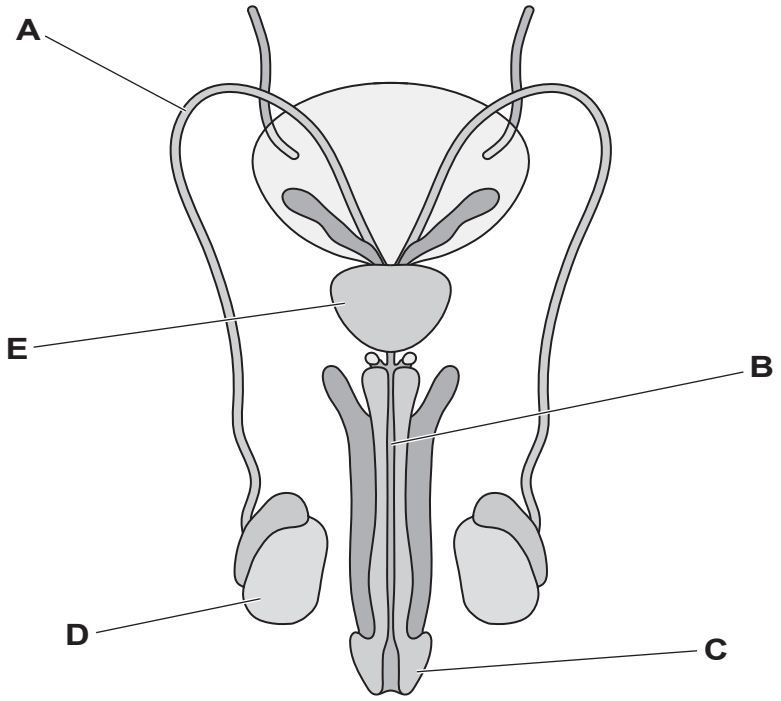

Fig. 1.1

State the letter from Fig. 1.1 that identifies the part:

that is a tube transporting excretory products .....

that secretes fluid for the formation of semen .....

where meiosis occurs. .....

[3]

(b) Fig. 1.2 is a diagram of a sperm cell.

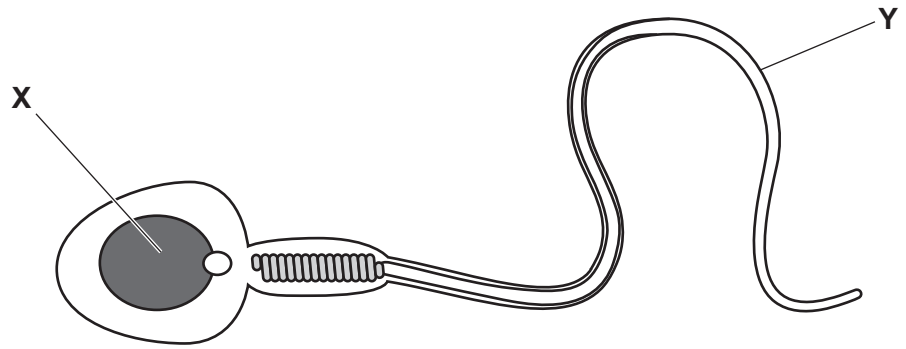

Fig. 1.2

(i) State how the arrangement of the chromosomes in the part labelled **X** in Fig. 1.2 is different to that of a human body cell.

.....

..... [1]

(ii) State the name and function of the adaptive feature labelled **Y** in Fig. 1.2.

name .....

function .....

.....

[2]

(c) The list shows the names of some specialised cells.

ciliated cell

egg cell

palisade mesophyll cell

red blood cell

root hair cell

white blood cell

Choose **one** cell from the list that:

contains a haploid nucleus .....

does not contain a nucleus .....

is found in the bronchi .....

is responsible for phagocytosis. .....

[4]

(d) Red blood cells and white blood cells are components of blood.

State the name of one other major component of blood.

..... [1]

[Total: 11]

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2 **(a)** A teacher investigates the reactions of the Group I metals, lithium, potassium and sodium, with water.

Table 2.1 shows their results.

Table 2.1

metal	observations
lithium	fizzes, moves across the surface of the water
potassium	fizzes violently, moves very quickly across the surface of the water, flame seen
sodium	fizzes strongly, moves very quickly across the surface of the water

(i) Deduce the order of reactivity of the metals.

..... most reactive

.....

..... least reactive

[2]

(ii) When potassium reacts with water a flame is seen.

State the colour of the flame.

..... [1]

(iii) Complete and balance the symbol equation for the reaction between sodium and water.

..... Na + ... H_2O → ..... + ...

[2]

(b) Sodium reacts with chlorine to make the **ionic compound** sodium chloride.

Fig. 2.1 shows the electronic structures of a sodium atom and a chlorine atom.

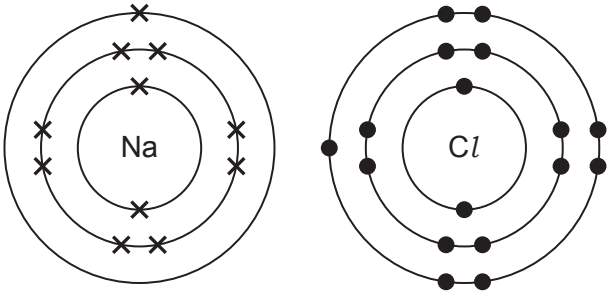

Fig. 2.1

(i) Draw the electronic structures of the sodium ion and chloride ion in the ionic compound sodium chloride. Show the charges on the ions.

[2]

(ii) Describe the structure of sodium chloride.

.....

.....

..... [2]

(iii) Explain why **molten** sodium chloride conducts electricity, but **solid** sodium chloride does not conduct electricity.

.....

..... [1]

[Total: 10]

3 A student investigates a spring.

The student adds slotted masses to the spring to increase the force applied to the spring as shown in Fig. 3.1.

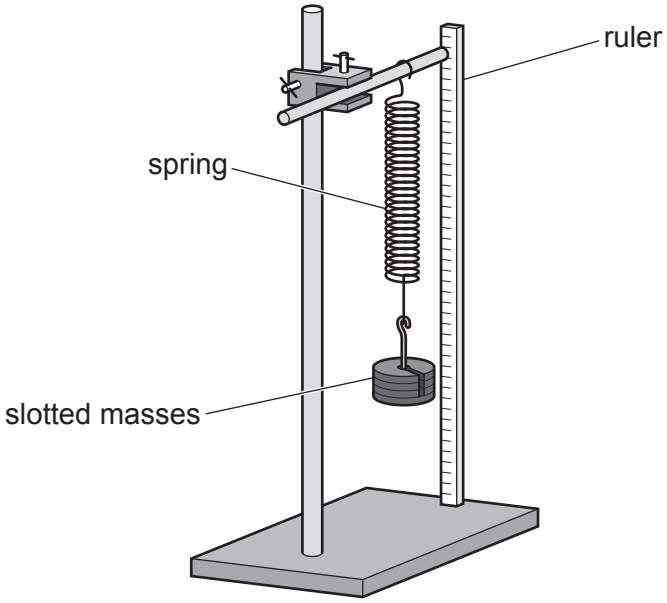

Fig. 3.1

(a) The student records the length of the spring as it extends.

Fig. 3.2 shows the results obtained by the student.

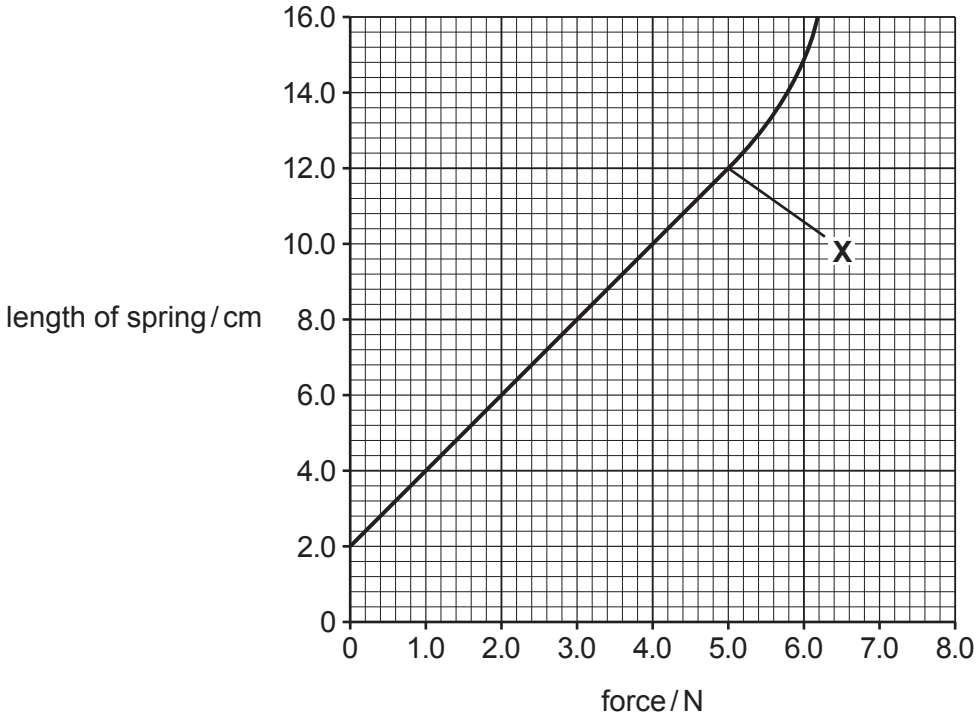

Fig. 3.2

(i) Use Fig. 3.2 to determine the original length of the spring.

..... cm [1]

(ii) Use Fig. 3.2 to calculate the spring constant of the spring.

spring constant = ... N/cm [2]

(iii) State the term used to describe point **X** on the graph.

..... [1]

(b) The slotted masses used by the student are made from steel.

Fig. 3.3 shows one of the slotted masses.

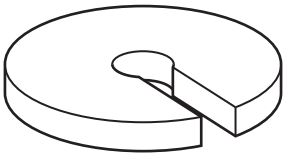

Fig. 3.3

Describe how the student determines the density of the steel used to make the slotted masses.

measurement 1 .....

.....

.....

measurement 2 .....

.....

.....

calculation .....

.....

.....

[3]

(c) Fig. 3.4 shows how a long spring can be used to demonstrate wave motion.

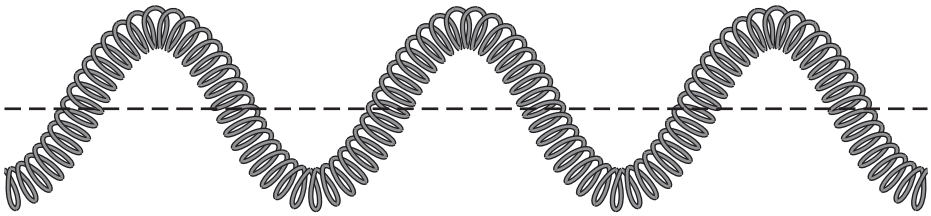

Fig. 3.4

(i) On Fig. 3.4 use a double headed arrow (↕ or ↔) to label the amplitude of the wave. [1]

(ii) The wave shown in Fig. 3.4 is a transverse wave.

Complete the sentence to describe the properties of a transverse wave.

Transverse waves are made by oscillations which act ..... to the direction of energy transfer. [1]

[Total: 9]

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4 **(a)** Phenylketonuria (PKU) is an inherited disorder controlled by a single gene.

People with PKU have to limit how much protein they eat.

The allele for PKU is recessive (**d**).

Fig. 4.1 is a pedigree diagram showing the inheritance of PKU in one family.

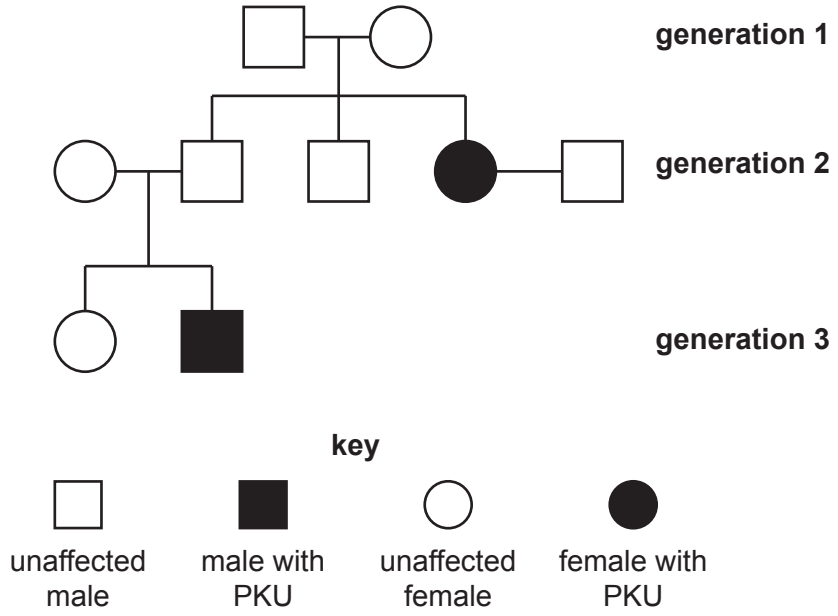


Fig. 4.1

(i) Use Fig. 4.1 to state the number of people:

that are homozygous recessive for PKU .....

with XX chromosomes. .....

[2]

(ii) The two people in generation 1 in Fig. 4.1 have the same genotype.

State this genotype.

..... [1]

(iii) State the percentage likelihood of an offspring having PKU if both parents have heterozygous genotypes.

..... [1]

(b) State the names of two diseases that are associated with protein-energy malnutrition.

1 .....

2 .....
[2]

(c) Table 4.1 shows some large nutrient molecules.

Complete Table 4.1 to name the smaller molecules from which they are made.

Table 4.1

large nutrient molecule	smaller molecules they are made from
glycogen	
protein	
starch	

[3]

(d) State the name of the enzyme that breaks down protein.

..... [1]

[Total: 10]

5 Electrolysis can be used to break down a substance into useful products.

Fig. 5.1 shows the electrolysis of dilute sulfuric acid.

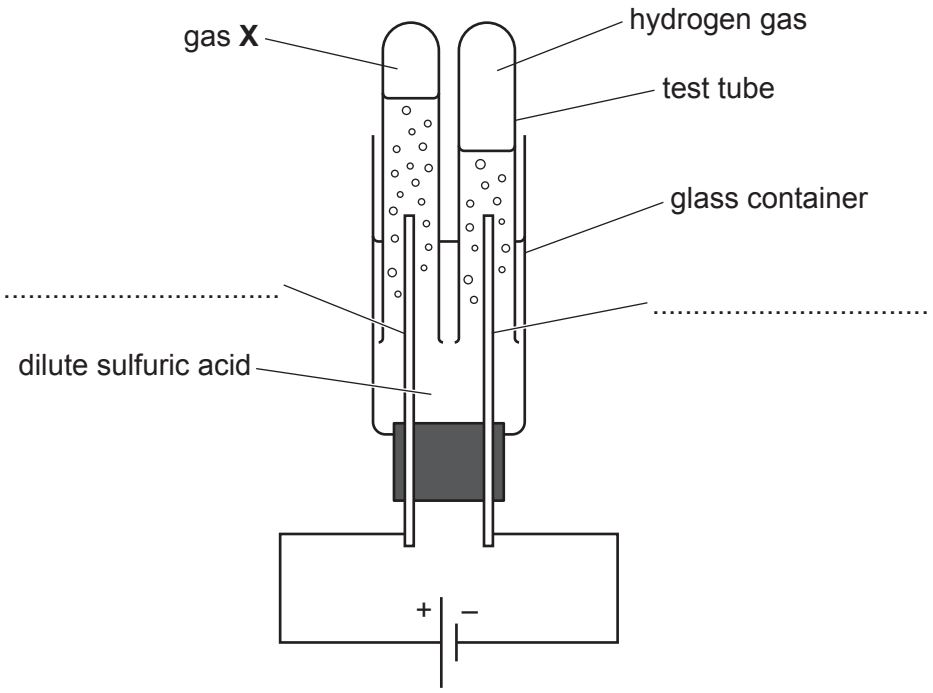


Fig. 5.1

(a) (i) Complete the labels on Fig. 5.1.

Choose words from the list.

anode

anion

cathode

cation

electrolyte

[2]

(ii) State the name of gas **X** in Fig. 5.1.

..... [1]

(iii) Hydrogen gas, H_2, is made at the negative electrode.

Complete and balance the ionic half-equation for this reaction.

..... + ... $e^- \rightarrow H_2$

[2]

(iv) State if the reaction in part **(iii)** is oxidation or reduction.

Explain your answer using ideas about electrons.

.....

..... [1]

(v) Describe the test for hydrogen and the observation for a positive result.

test .....

result .....
[2]

(b) In an experiment a student passes electricity through dilute sulfuric acid and collects 6 dm^3 of hydrogen gas.

Calculate the mass of 6 dm^3 of hydrogen gas.

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

mass of hydrogen gas = ... g [3]

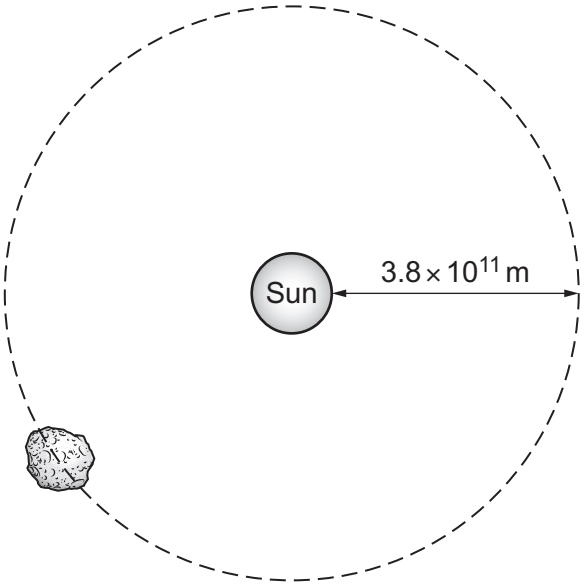
[Total: 11]

6 Asteroids are large rocks which orbit the Sun.

Fig. 6.1 shows a diagram of an asteroid.

Fig. 6.1

(a) Fig. 6.2 shows the asteroid orbiting the Sun.



Not to scale

Fig. 6.2

It takes 1245 days for the asteroid to complete one full orbit of the Sun.

The asteroid orbits in a circle 3.8×10^{11} m from the Sun.

Show that the average speed of the asteroid is 22 000 m / s.

[3]

(b) Scientists have found evidence that asteroids contain the isotope strontium-87.

(i) Strontium-87 is produced by the decay of rubidium-87.

Use correct nuclide notation to complete the decay equation for rubidium-87.

$$^{87}_{37}\text{Rb} \rightarrow {}^{87}_{38}\text{Sr} + {}^{\cdots\cdots}_{\cdots\cdots}\ \cdots\cdots$$

[1]

(ii) Fig. 6.3 shows how a sample of rubidium-87 decays.

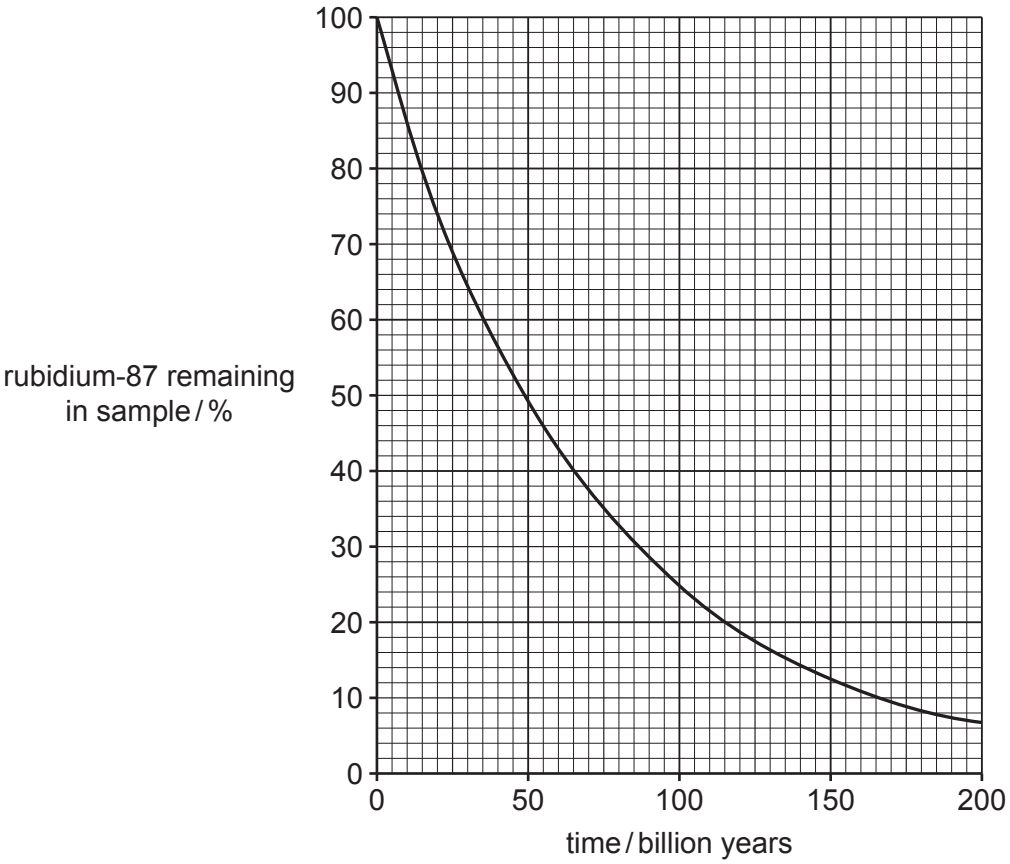


Fig. 6.3

Use Fig. 6.3 to determine the half-life of rubidium-87.

Give a suitable unit for your answer.

half-life = ... unit ..... [2]

(iii) Asteroids are thought to be 5 billion years old.

Use Fig. 6.3 to determine the percentage of rubidium-87 that has decayed to strontium-87 in the asteroid.

percentage = ... % [1]

[Total: 7]

7 **(a)** A student investigates the effect of light intensity on the rate of photosynthesis.

The student places a lamp 10 cm from an aquatic plant.

The student records the number of bubbles of oxygen released in two minutes.

The student repeats this investigation increasing the distance of the lamp each time.

Table 7.1 shows the results.

Table 7.1

distance of lamp from aquatic plant / cm	number of oxygen bubbles released in two minutes
10	102
20	85
30	62
40	29
50	9

The number of bubbles of oxygen the aquatic plant releases is used to indicate the rate of photosynthesis.

(i) Calculate the rate of oxygen bubbles released when the lamp is placed 30 cm from the aquatic plant.

..... bubbles / min [1]

(ii) Complete the sentences to describe and explain the results in Table 7.1.

Decreasing the distance of the lamp from the aquatic plant

..... the light intensity.

Light energy is converted into ..... energy in molecules.

This transfer of energy is done by ..... in the chloroplasts.

During this process oxygen is produced and ..... are synthesised. [4]

(iii) The investigation is repeated with much less carbon dioxide dissolved in the water.

Explain the effect this will have on the number of oxygen bubbles released.

.....

.....

.....

..... [2]

(b) Photosynthesis is an enzyme-controlled reaction.

State **two** conditions that cause enzymes to denature.

1 .....

2 .....
[2]

(c) A plant will grow towards a source of light.

(i) State the name of this tropic response.

..... [1]

(ii) State the name of the chemical that causes this tropic response.

..... [1]

[Total: 11]

8 **(a)** Ammonia is manufactured in the Haber process.

Fig. 8.1 describes the Haber process.

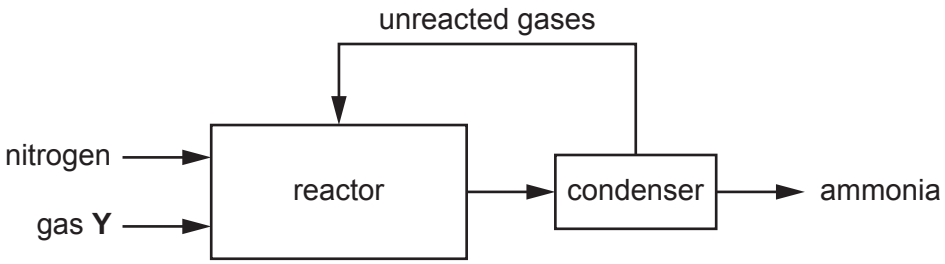


Fig. 8.1

(i) Gas **Y** is obtained from the reaction of methane with steam.

State the name of gas **Y**.

..... [1]

(ii) State the temperature and pressure used in the reactor.

temperature ..... °C

pressure ..... atmospheres
[2]

(iii) Iron is also used in the Haber process.

State and explain why iron is used.

.....

.....

..... [2]

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

One stage of this process involves the reaction of iron oxide, Fe_2O_3, with carbon monoxide.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

Calculate the mass of iron made when 400 kg of iron oxide reacts with excess carbon monoxide.

[A_r: Fe, 56; O, 16]

mass of iron = ... kg [2]

(c) (i) Calcium carbonate, $CaCO_3$, in limestone is used to help remove impurities from the iron.

$$CaCO_3 \rightarrow CaO + CO_2$$

$$CaO + SiO_2 \rightarrow CaSiO_3$$

Complete the sentences to describe how calcium carbonate removes impurities.

The calcium carbonate in the limestone ....

to form ....

This then reacts with the ..... impurities in the hematite to

produce ..... .

This is separated from the iron and used to make road surfaces.

[4]

(ii) CaO is a **basic** oxide. SiO_2 is an **acidic** oxide.

Explain why.

CaO is a basic oxide because .....

SiO_2 is an acidic oxide because .....

[1]

[Total: 12]

9 Fig. 9.1 shows two identical infrared heating lamps that are heating two metal cubes. The lamps are at the same distance from the cubes. The lamps are heating each cube for the same time.

One lamp is heating the dull white metal cube and the other the dull black metal cube.

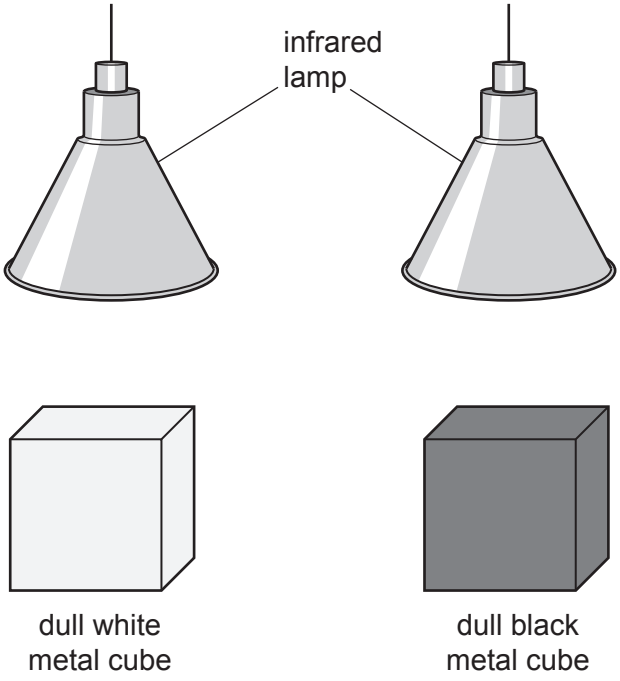


Fig. 9.1

(a) (i) Explain why the temperature of the dull black cube rises more than the temperature of the dull white cube.

..... [1]

(ii) The dull black metal cube is replaced by a shiny black metal cube.

Explain why the temperature of the shiny black cube rises less than the temperature of the dull black cube.

..... [1]

(iii) Infrared radiation emitted by the lamps includes radiation with a wavelength of 0.75 mm.

Calculate the frequency of this infrared radiation.

frequency = ... Hz [3]

(iv) Thermal energy is conducted through the metal cubes.

Describe the process of conduction in a metal.

.....

.....

.....

.....

.....

..... [3]

(b) One of the cubes is now filled with hot water. A student uses a digital thermometer containing a thermocouple to measure the temperature of the water inside the cube.

(i) Describe the structure of a thermocouple used to measure temperature.

.....

.....

..... [1]

(ii) The thermocouple produces an electromotive force (e.m.f.).

Place ticks (✓) in Table 9.1 to compare e.m.f. to potential difference.

Table 9.1

	electromotive force only	potential difference only	electromotive force and potential difference
measured in volts			
measured using a voltmeter			
equal to the energy supplied by a source in driving a charge around a circuit			

[3]

[Total: 12]

10 (a) Scientists estimate the percentage of energy used from anaerobic respiration and aerobic respiration as the intensity of exercise increases.

Fig. 10.1 is a graph of the results.

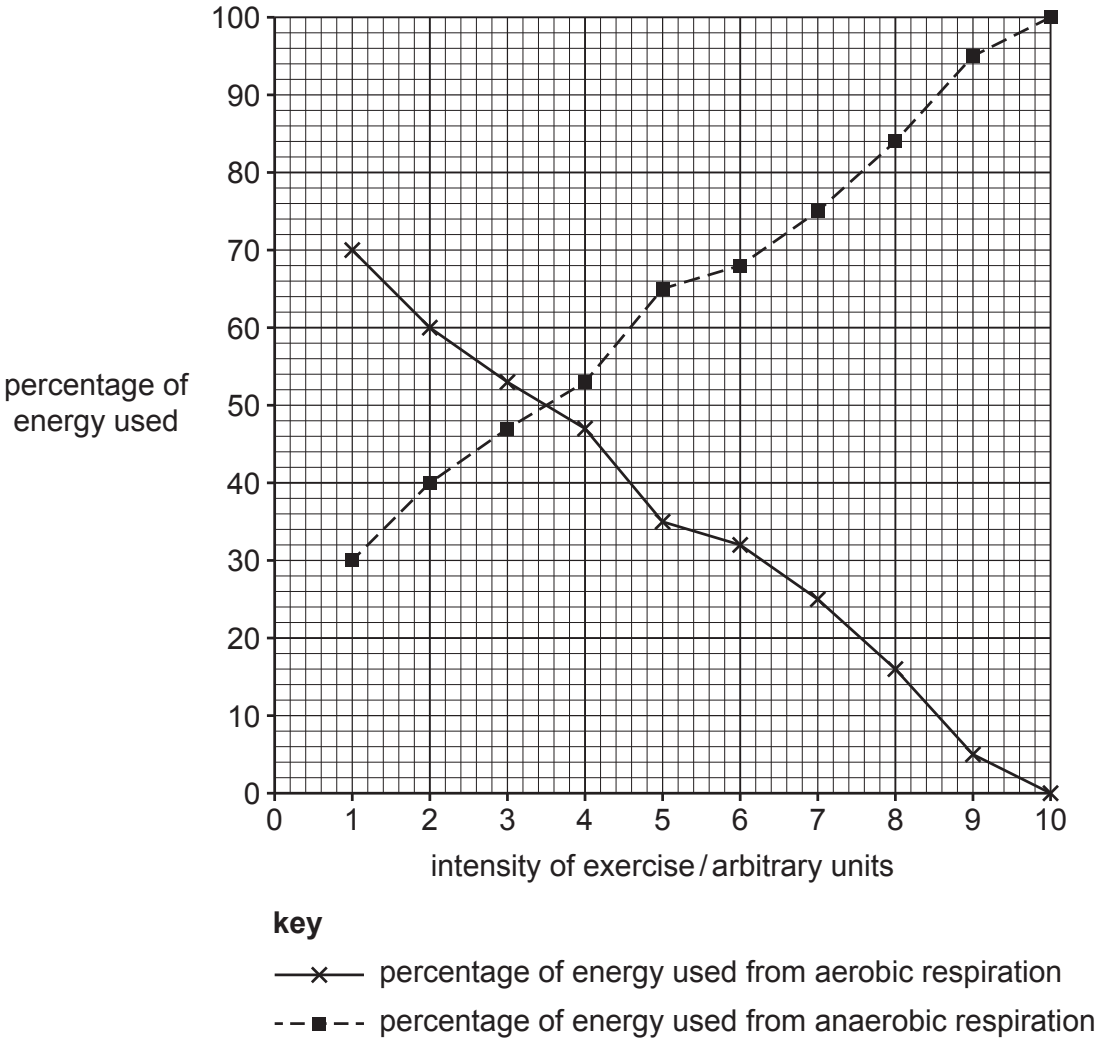


Fig. 10.1

(i) Describe the results, shown in Fig. 10.1, as the intensity of exercise increases.

.....

.....

..... [1]

(ii) Identify the intensity of exercise when the percentage of energy used from aerobic respiration and the percentage of energy used from anaerobic respiration are equal.

..... arbitrary units [1]

(b) Explain why aerobic respiration in muscles is better for the body than anaerobic respiration.

.....

.....

.....

.....

..... [3]

(c) Mammals have a double circulatory system.

(i) Tick (✓) **all** the boxes that show the advantages of a double circulatory system.

allows the passage of nervous impulses to body tissues	
allows higher pressure of blood to the body tissues	
allows higher pressure of blood to the lungs	
prevents diffusion of substances from the blood	
separates oxygenated and deoxygenated blood	

[2]

(ii) Describe how the heart pumps blood.

.....

.....

..... [1]

[Total: 8]

11 **(a)** Butane, C_4H_{10}, is an alkane.

Complete the sentence about alkanes.

Alkanes are ..... hydrocarbons whose molecules contain only ..... covalent bonds. [2]

(b) Table 11.1 shows the energy given out when 1 g of different alkanes burns.

Table 11.1

alkane	energy given out / kJ
butane	49.2
ethane	52.6
methane	55.6
propane	50.4

(i) State the relationship between the number of carbon atoms in the alkane and the energy given out.

.....

..... [1]

(ii) State the name given to any reaction that gives out energy.

..... [1]

(c) Butane is a small alkane molecule.

Large alkane molecules are cracked into smaller, more useful molecules.

The equation shows the cracking of $C_{24}H_{50}$ to make $C_{10}H_{22}$ and **one** other product.

Complete the equation.

$$C_{24}H_{50} \rightarrow C_{10}H_{22} + ...$$

[1]

(d) Table 11.2 shows the percentage (%) supply and demand for some of the different fractions obtained from crude oil.

Table 11.2

fraction	% supply	% demand
refinery gases	2	4
gasoline (petrol)	5	23
naphtha	8	5
kerosene	12	7
diesel oil	17	23
fuel oil	56	38

Suggest and explain which fraction is cracked to obtain more gasoline (petrol).

.....

.....

.....

..... [2]

[Total: 7]

12 Fig. 12.1 shows a large electromagnet used to lift scrap metal.

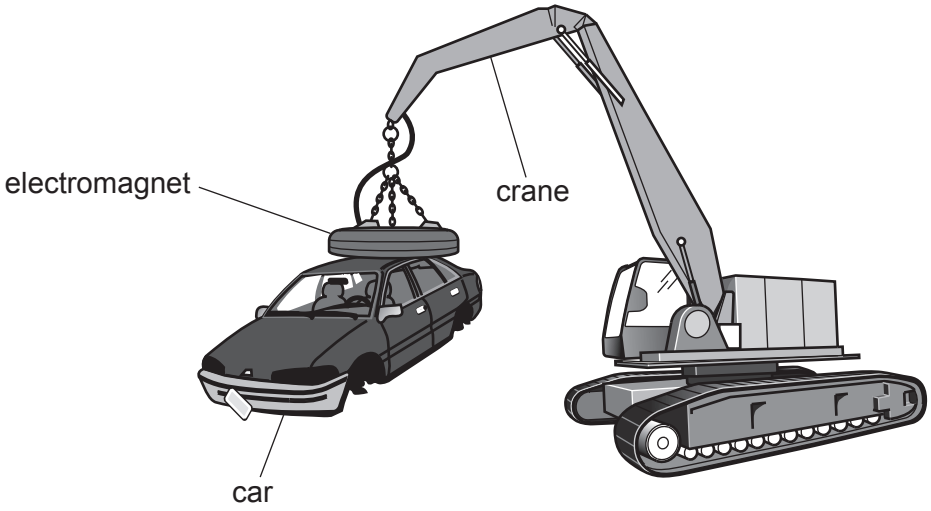


Fig. 12.1

(a) The electromagnet lifts the car to a height of 15 m. The car has a mass of 1200 kg.

Calculate the work done on the car when it is lifted to a height of 15 m.

The gravitational field strength is $g = 10\,\text{N/kg}$.

work done = ... J [2]

(b) The electromagnet is made from a solenoid.

Fig. 12.2 shows a solenoid.

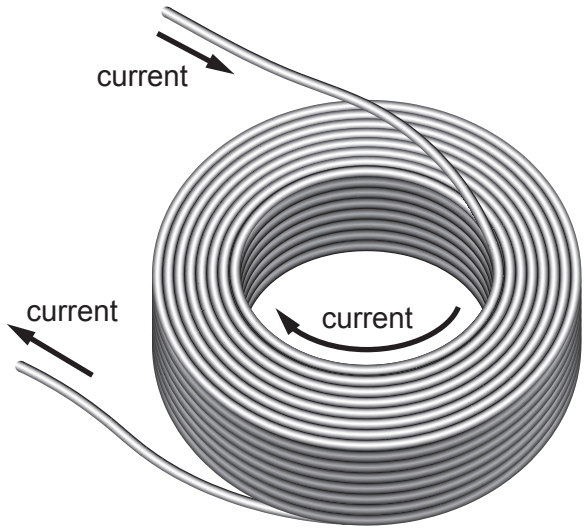


Fig. 12.2

(i) On Fig. 12.2 draw the pattern of the magnetic field produced when a current passes through the solenoid.

Include an arrow showing the direction of the magnetic field. [2]

(ii) The solenoid uses a current of 50 A.

Calculate the amount of charge which flows through the solenoid in 30 s.

State the unit for your answer.

charge = ... unit ..... [3]

(iii) The solenoid has a resistance of 5.0 Ω when the current is 50 A.

Calculate the power of the electromagnet.

power = ... W [4]

(c) Electromagnets can be made much stronger than permanent magnets.

State **one other** advantage of using an electromagnet to lift scrap metal.

.....

..... [1]

[Total: 12]

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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.).