	Centre Number		Candidate Number
Candidate Name _____			

International General Certificate of Secondary Education
UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATIONS SYNDICATE

CO-ORDINATED SCIENCES   **0654/3**

PAPER 3
OCTOBER/NOVEMBER SESSION 2001   2 hours

Candidates answer on the question paper.
No additional materials are required.

TIME   2 hours

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 24.

FOR EXAMINER'S USE	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
TOTAL	

This question paper consists of 22 printed pages and 2 blank pages.

[Turn over

1 The electronic structures of five atoms, **A** to **E**, are shown in Fig. 1.1.

atom	1st shell	2nd shell	3rd shell	4th shell
A	2			
B	2	5		
C	2	8	2	
D	2	8	7	
E	2	8	8	2

Fig. 1.1

(a) Explain, in terms of electronic structure, which of the atoms in Fig. 1.1

   (i) are of elements in the same group of the Periodic Table;

   ....

   .... [1]

   (ii) does not form any chemical bonds;

   ....

   .... [1]

   (iii) forms an ion by gaining one electron.

   ....

   .... [1]

(b) Fig. 1.2 shows a schematic diagram of the industrial process used to make ammonia.

nitrogen   hydrogen

catalyst
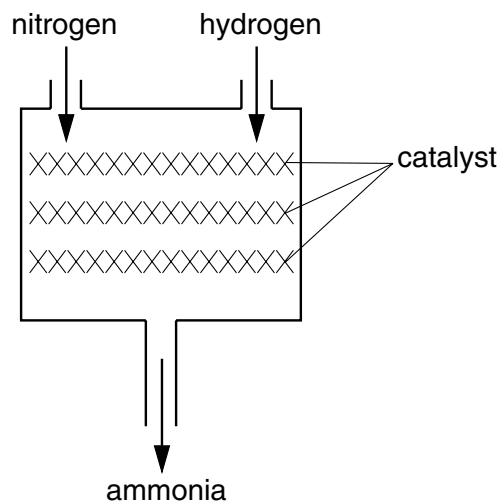
ammonia

Fig. 1.2

(i) Write the balanced equation for the formation of ammonia.

.... [2]

(ii) Name **one** gas, other than ammonia, which is present in the mixture that leaves the reaction vessel. Explain briefly why the gas you have named is present.

....

....

.... [2]

(c) Much of the ammonia produced in industry is used to make nitric acid. In this process, ammonia gas is mixed with air and passed over a heated catalyst.

(i) Write the chemical formula of nitric acid.

.... [1]

(ii) Name the substance which oxidises ammonia in this process.

.... [1]

(d) Ammonia reacts with acids to make ammonium salts which are used as fertilisers.

(i) State the type of reaction which occurs between ammonia and acids.

.... [1]

(ii) One salt used in fertilisers is ammonium hydrogenphosphate, $(NH_4)_2HPO_4$.

The formula of the ammonium ion is NH_4^+.

Deduce the formula of the hydrogenphosphate ion.

Explain your answer.

....

....

.... [2]

[Turn over

2 **(a)** A mutation is an unpredictable change in the DNA of a cell.

    (i) In which part of a cell is the DNA found?

    .... [1]

    (ii) State **one** factor that increases the chance of a mutation occurring.

    .... [1]

    (iii) Explain why a mutation in a cell in the testes of a man may cause more harm in his child than in the man himself.

    ....

    ....

    ....

    .... [2]

(b) A mutation occurred in a cell in an anther of a flower, forming a new allele. The cell divided to form pollen grains that contained this new allele.

The normal allele, **A**, was dominant and coded for red flowers. The new allele, **a**, was recessive and coded for white flowers.

One of the pollen grains containing allele **a** landed on the stigma of a flower whose ovule contained the normal allele **A**. The fertilised ovule developed into a seed, which grew into a new plant that produced flowers.

    (i) Describe how the allele **a** travelled from the pollen grain to the ovule.

    ....

    ....

    ....

    .... [2]

    (ii) State the genotype of the new plant, and the colour of its flowers.

    genotype ……………………………   *flower colour* .... [2]

(iii) The pollen produced by the new plant fertilised its own ovules. Some of the resulting offspring had red flowers, and some had white flowers.

Use a genetic diagram to explain how this occurred.

[3]

[Turn over

3 **(a)** Fig. 3.1 shows some apparatus used by two students.
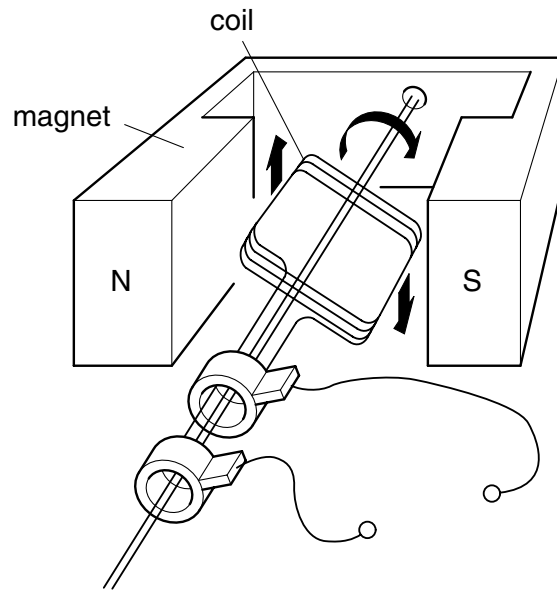
coil

magnet

N

S

Fig. 3.1

Student **A** says that it is an electric motor.

Student **B** says that it is a generator.

Explain carefully why both students could be correct.

....

....

....

....

....

.... [4]

(b) Fig. 3.2 shows a transformer whose primary circuit is connected to a d.c. supply.

A spark will be
produced here if
the potential difference
between these points
is large enough.

primary   secondary
circuit   circuit
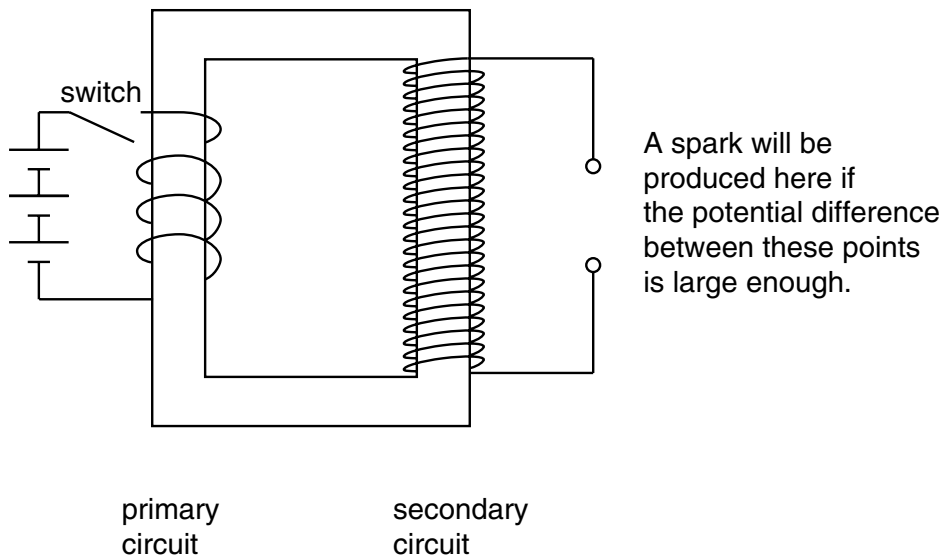
Fig. 3.2

Nothing happens in the secondary circuit except when the current in the primary circuit is switched off. Then, a spark is produced.

(i) Suggest why nothing happens in the secondary circuit while the current is flowing steadily in the primary circuit.

....

.... [1]

(ii) Suggest why a spark is produced when the current in the primary circuit is switched off.

....

.... [1]

[Turn over

4 Diesel is a liquid fuel obtained from crude oil (petroleum).

(a) (i) Name the process which is used to separate diesel from crude oil.

.... [1]

(ii) Gasoline is also obtained from crude oil. The molecules in gasoline are, on average, smaller than those in diesel.

State two ways in which the physical properties, other than colour, of gasoline differ from those of diesel.

1. ....

....

2. ....

.... [2]

(b) Dodecane is an alkane found in diesel. A sample of dodecane is thought to be contaminated with alkenes.

Describe how this sample of dodecane could be tested to see if it contained any alkenes.

....

....

....

.... [3]

Biodiesel is a fuel made from oil obtained from the seeds of plants such as sunflower and rape. It can be used in engines instead of diesel produced from crude oil.

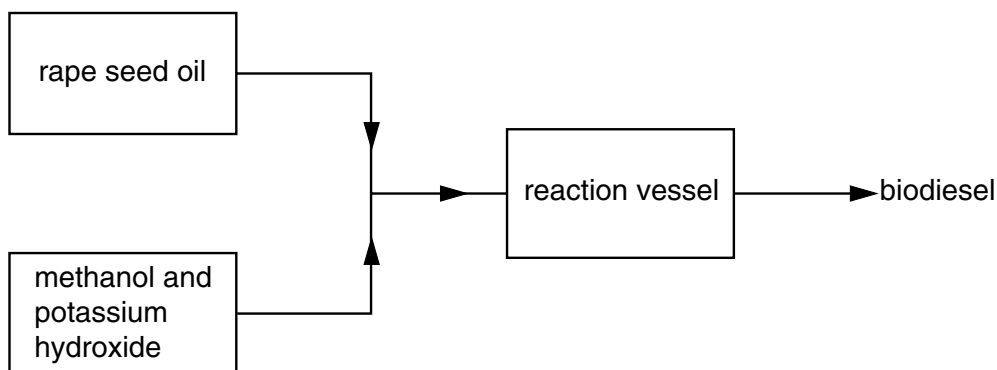Fig. 4.1 shows the main steps in producing biodiesel from rape seeds.

Fig. 4.1

(c) Methanol has the formula CH_4O.

Calculate the mass of one mole of methanol. Show your working.

.... [2]

(d) Biodiesel is the preferred fuel for use in the engines of boats used on rivers and canals.

Suggest and explain why each of the differences shown in Fig. 4.2 makes biodiesel a better fuel than diesel for use in the engines of these boats.

sulphur content	much lower in biodiesel compared to diesel
carbon monoxide emissions	lower in biodiesel compared to diesel
biodegradability	bacteria consume biodiesel in the environment more quickly than they consume diesel

Fig. 4.2

....

....

....

....

....

.... [4]

[Turn over

5 Fig. 5.1 shows the nutrient content in 100 g of four foods. Wheat flour and cabbage are derived from plants, while chicken and eggs are from animals.

food	energy /kJ	protein /g	fat /g	carbo-hydrate /g	iron /mg	calcium /mg	vitamin C /mg
wheat flour	1340	13.0	2.0	66.0	4.0	35	0
cabbage	60	1.7	0	2.0	0.4	40	20
chicken	920	23.0	14.0	0	0.8	0	0
eggs	630	12.3	10.9	0	2.0	50	0

Fig. 5.1

(a) Calculate how many times greater the carbohydrate content of cabbage is than its vitamin C content.

.... [2]

(b) State the nutrient shown in Fig. 5.1 that is found in both plant foods but neither animal food, and suggest why this is so.

....

....

.... [2]

(c) Carbohydrates are a major source of energy in food.

　(i) Which two other nutrients are sources of energy?

　　1. ....　　2. .... [2]

　(ii) Describe how energy is released from the carbohydrate glucose inside a cell.

　　..

　　..

　　.. [2]

(d) Describe where and how fats are digested in the human alimentary canal.

....

....

....

.... [3]

(e) Fig. 5.2 shows a food chain and a pyramid of biomass based on this food chain.

cabbage ⟶ chicken ⟶ human

humans

chickens

cabbages
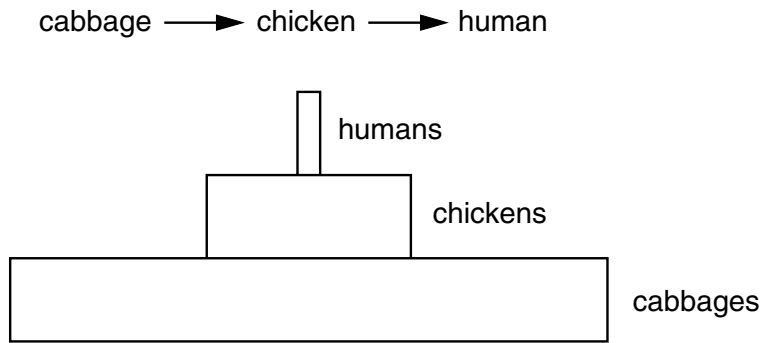
Fig. 5.2

(i) Explain why the pyramid of biomass is this shape.

....

....

....

.... [2]

(ii) The pyramid of biomass indicates that we could obtain more energy from the same area of land if we ate plant products rather than animal products. However, in many parts of the world, most farmers keep animals and eat animal products such as milk, eggs and meat.

Suggest reasons for this.

....

....

....

....

.... [2]

[Turn over

6 **(a)** A popular cartoon film shows a cat chasing a mouse. As the mouse runs past the cat, at time = 0, the cat starts chasing the mouse.
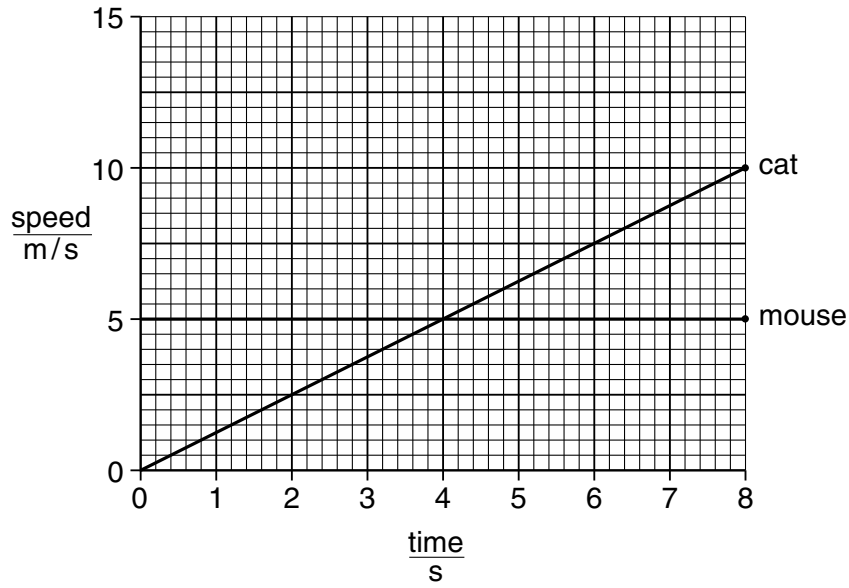

Fig. 6.1

The subsequent movements of the cat and mouse are described by the graph in Fig. 6.1. Using the graph, show that the cat caught the mouse at time = 8 seconds. You will need to calculate the distance travelled by both the cat and the mouse and show your working.

....

.... [2]

(b) The cat has a mass of 2 kg and jumps 2 m vertically upwards into a tree.

If the gravitational field strength is 10 N / kg, calculate the work done by the cat.

Show your working and state any assumptions that you make.

....

.... [3]

(c) The mouse has crept along a narrow wooden beam, pivoted in the middle, and is sitting on a heavy stone. The stone and mouse have a combined weight of 100 N. The cat sits on the beam and balances it. See Fig. 6.2.
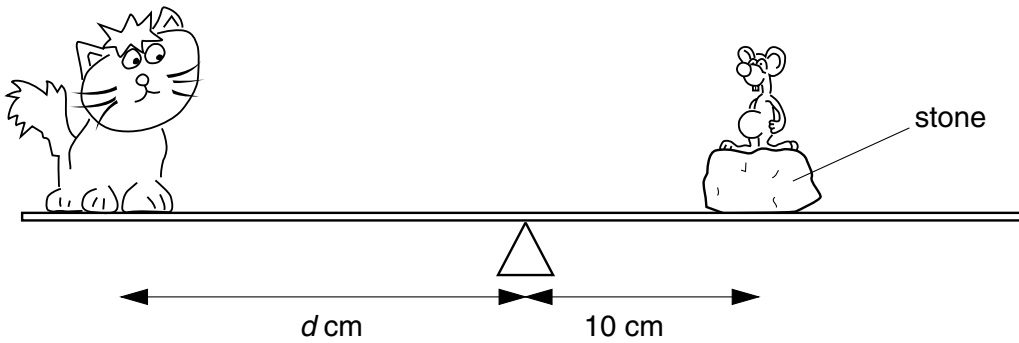

Fig. 6.2

(i) Calculate the distance *d* cm when the beam is balanced.

Show your working and state any formula that you use.

.... [3]

(ii) Describe and explain what happens if the cat walks along the beam towards the mouse.

....

....

.... [2]

[Turn over

7 Glucose is changed into ethanol (alcohol) when wine is produced from grape juice.

(a) The equation for the reaction is shown below.

$$C_6H_{12}O_6 \longrightarrow 2C_2H_6O + 2CO_2$$
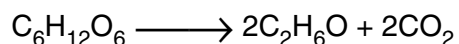
(i) Name the type of chemical bonding in glucose.

.... [1]

(ii) The displayed formula of carbon dioxide is O=C=O.

Draw a diagram to show how the outer electrons are arranged in one molecule of carbon dioxide.

[2]

(b) A student investigates the effect of temperature on the reaction rate.

The reaction is catalysed by enzymes present in the grape juice.

The student predicts that the rate of reaction would be much greater at 80 °C than at 20 °C.

Explain why his prediction is **not** correct.

....

....

.... [2]

(c) The pH value of wine is below 7 because it contains acids, including citric acid and tartaric acid.

(i) Describe how a solution of sodium hydroxide could be used to compare the overall acid content of two wines.

....

....

....

....

....

....

....

.... [4]

(ii) A sample of wine was found to have a tartaric acid concentration of $0.04 \, mol/dm^3$.

Calculate the mass of tartaric acid in $1 \, dm^3$ of this wine. The relative formula mass of tartaric acid is 150. Show your working.

.... [2]

(d) A breathalyser is a device used to test exhaled air for the presence of ethanol, C_2H_6O. In one type of breathalyser, ethanol is converted into ethanoic acid, $C_2H_4O_2$.

Suggest the type of chemical reaction which occurs in this breathalyser.

Explain your answer.

....

.... [2]

[Turn over

8 Radar uses microwaves with a frequency of about 10 000 MHz. A short pulse is sent from a transmitter, reflected by an aircraft and picked up by a receiver next to the transmitter. The time it takes for the wavefront to make the journey there and back is measured. See Fig. 8.1.
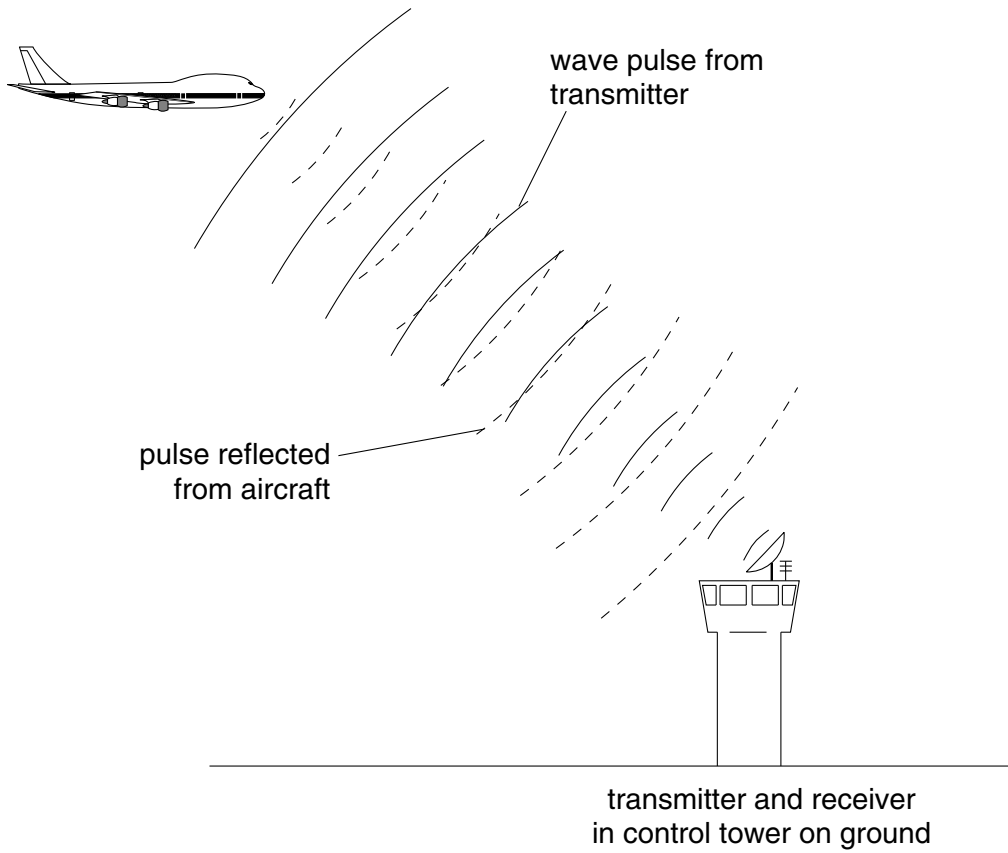
wave pulse from transmitter

pulse reflected from aircraft

transmitter and receiver in control tower on ground

Fig. 8.1

(a) (i) Explain the meaning of the term *frequency*.

....

.... [1]

(ii) Microwaves travel at the speed of light, 300 000 000 m / s.

Calculate the wavelength of the microwaves.

Show your working and state any formula that you use.

.... [3]

(iii) The aircraft was 5000 m away from the transmitter.

Calculate the time interval between the transmission of the pulse and its arrival at the receiver.

Show your working and state any formula that you use.

.... [2]

(b) Radio signals are electromagnetic waves. They can be either *digital* or *analogue*.

Explain the difference between these two terms.

....

....

.... [2]

(c) Light signals can be sent through optical fibres.

Explain how this happens.

....

....

.... [2]

[Turn over

9 Fig. 9.1 shows a section through an eye of a person looking at a candle.
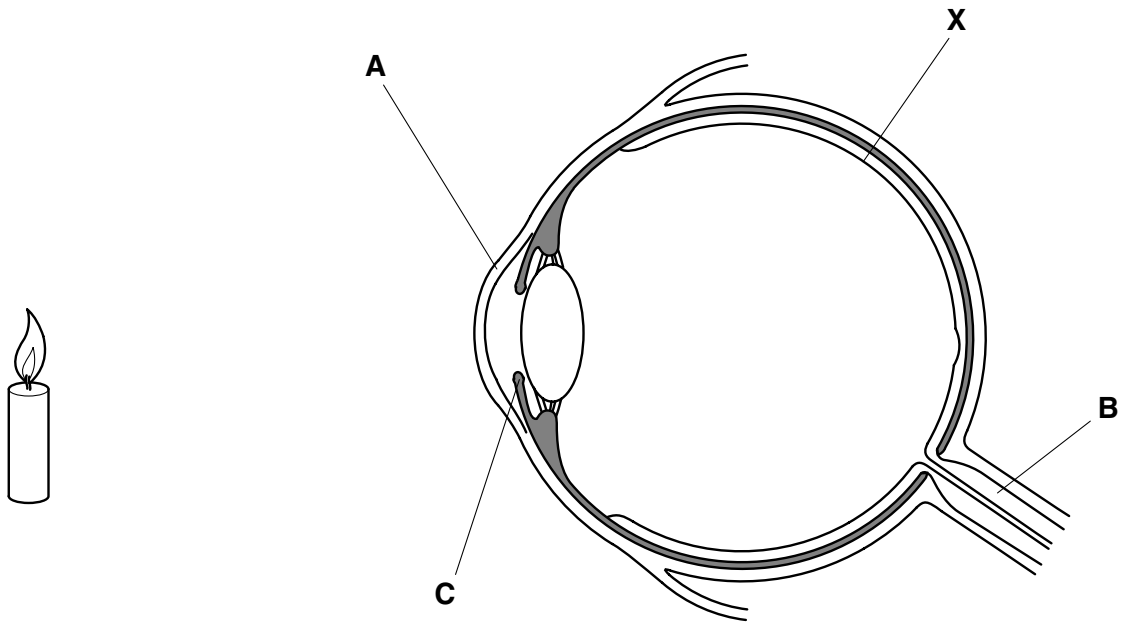
Fig. 9.1

(a) Name the parts labelled **A**, **B** and **C**.

A ....

B ....

C .... [3]

(b) On the diagram, draw **two** light rays from the **top** of the candle flame to show how its image is focused on to the retina. [3]

(c) Describe how the shape of the lens is changed when the eye focuses on an object that is further away from the eye.

....

....

....

....

.... [3]

(d) A boy catches sight of a ball out of the corner of his eye, so that the image is focused on the area marked **X**.

Explain why he cannot tell the colour of the ball.

....

....

.... [2]

[Turn over

10 (a) Fig. 10.1 shows the current being measured in different parts of a circuit, which includes three identical lamps and three ammeters, **P**, **Q** and **R**.
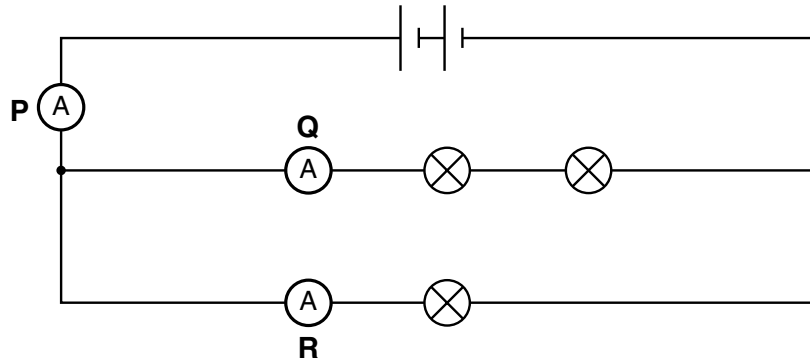

Fig. 10.1

(i) Which ammeter, **P**, **Q** or **R**, shows the largest current?

Explain your answer.

....

.... [2]

(ii) Which ammeter, **P**, **Q** or **R**, shows the smallest current?

Explain your answer.

....

.... [2]

(b) Fig. 10.2 shows a similar circuit, containing three identical resistors but no ammeters.

Fig. 10.2

(i) A voltmeter connected across **AB** reads 3 V.
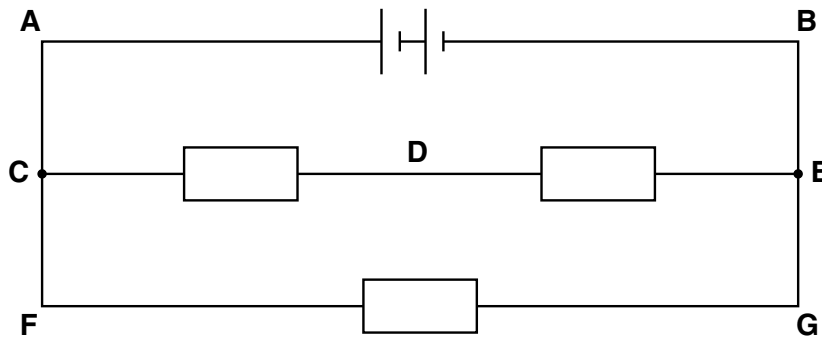
What would the voltmeter read when connected across

CD, ……………………

FG? ……………………   [2]

(ii) The current through **CD** is 0.1 A.

Calculate the resistance of one resistor.

Show your working and state any formula that you use.

.... [2]

(iii) Calculate the total resistance of the circuit between **C** and **E**.

Show your working and state any formula that you use.

.... [2]

22

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23

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DATA SHEET
The Periodic Table of the Elements

Group

I	II												III	IV	V	VI	VII	0
																		4 **He** Helium 2
7 **Li** Lithium 3	9 **Be** Beryllium 4												11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
23 **Na** Sodium 11	24 **Mg** Magnesium 12												27 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulphur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18
39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	64 **Cu** Copper 29	65 **Zn** Zinc 30		70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
85 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	**Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48		115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	139 **La** Lanthanum 57 *	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80		204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	**Po** Polonium 84	**At** Astatine 85	**Rn** Radon 86
Fr Francium 87	226 **Ra** Radium 88	227 **Ac** Actinium 89 †																

1 **H** Hydrogen 1

*58-71 Lanthanoid series

| 140 **Ce** Cerium 58 | 141 **Pr** Praseodymium 59 | 144 **Nd** Neodymium 60 | **Pm** Promethium 61 | 150 **Sm** Samarium 62 | 152 **Eu** Europium 63 | 157 **Gd** Gadolinium 64 | 159 **Tb** Terbium 65 | 162 **Dy** Dysprosium 66 | 165 **Ho** Holmium 67 | 167 **Er** Erbium 68 | 169 **Tm** Thulium 69 | 173 **Yb** Ytterbium 70 | *175 **Lu** Lutetium 71 |

†90-103 Actinoid series

| 232 **Th** Thorium 90 | **Pa** Protactinium 91 | 238 **U** Uranium 92 | **Np** Neptunium 93 | **Pu** Plutonium 94 | **Am** Americium 95 | **Cm** Curium 96 | **Bk** Berkelium 97 | **Cf** Californium 98 | **Es** Einsteinium 99 | **Fm** Fermium 100 | **Md** Mendelevium 101 | **No** Nobelium 102 | **Lr** Lawrencium 103 |

Key

a
X
b

a = relative atomic mass
X = atomic symbol
b = proton (atomic) number

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