Candidate Name Mark Scheme

Centre Number | Candidate Number

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

CO-ORDINATED SCIENCES 0654/3

PAPER 3

Tuesday 18 NOVEMBER 1997 Morning 2 hours

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

TIME 2 hours

Biol ✓
Chem ✓
Phys ✓

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.

You may use a calculator.

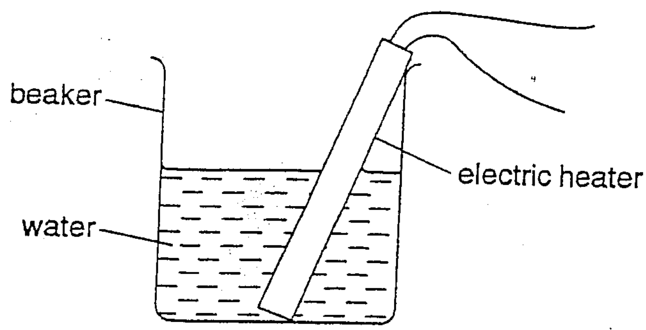
FOR EXAMINER'S USE	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
TOTAL	

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

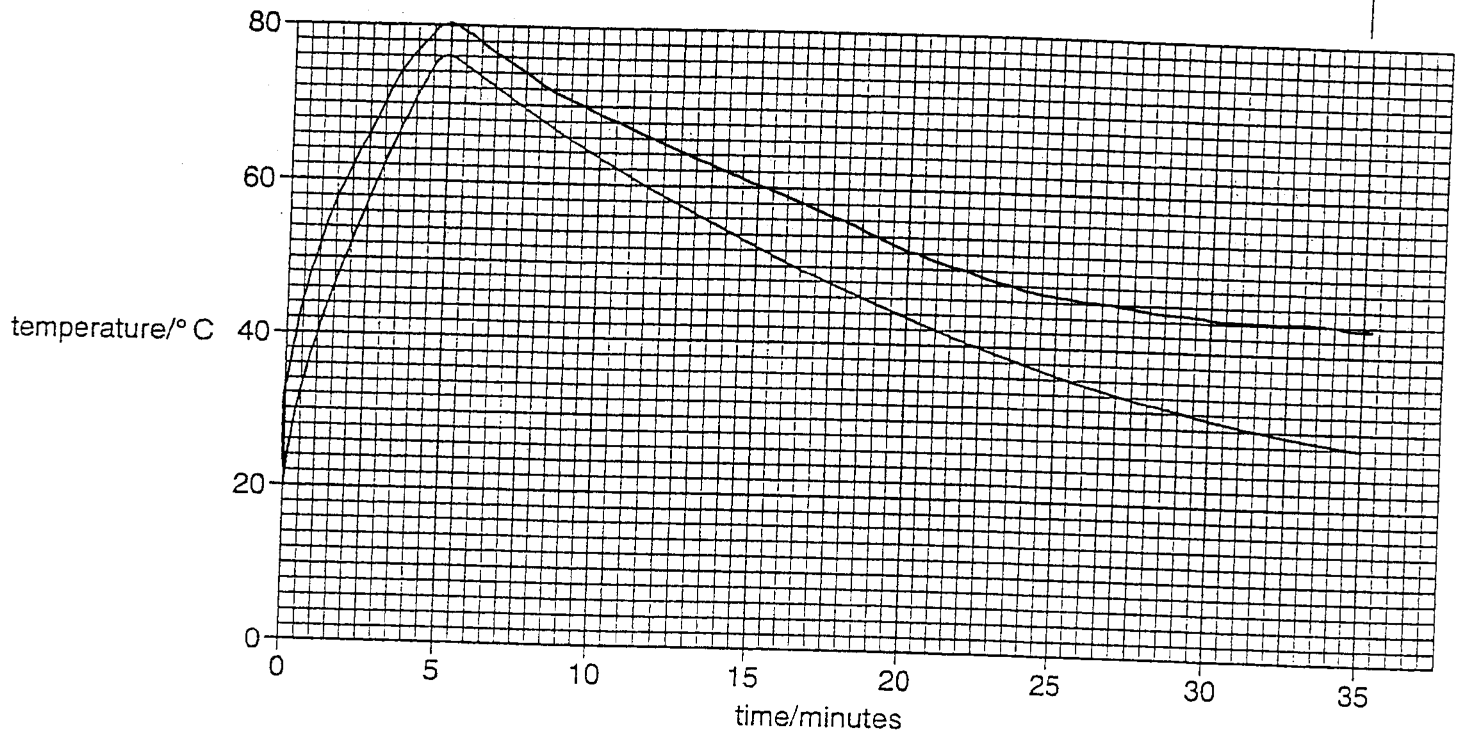
SB (SLC) QK73147

For Examiner's Use

1 Some water is heated in a container with no insulation using an electric heater, and then allowed to cool.



The graph shows how the temperature of the water changed.



(a) (i) On the grid, sketch a line to show the results which might have been obtained if the container had been insulated. [2]

(ii) Explain your answer.

Less heat escapes to the air

....[1]

For Examiner's Use

(b) To heat 1000 cm^3 of water by 1 °C needs 4200 joules. If the heater raises the temperature of 500 cm^3 of water by 15 °C, calculate how much energy is supplied to the water.

Show your working.

$E = mc(\theta_2 - \theta_1) = 0.5 \times 4200 \times 15$

$= 31\,500$ J

[3]

(c) (i) The water came from a limestone region. The water deposited scale on the heater. How would this affect the time taken for the heater to raise the temperature of the water by 15 °C?

Explain your answer.

- It would take a longer time
- The limescale would act as an insulator

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

(ii) Name a substance contained in the scale around the heating element.

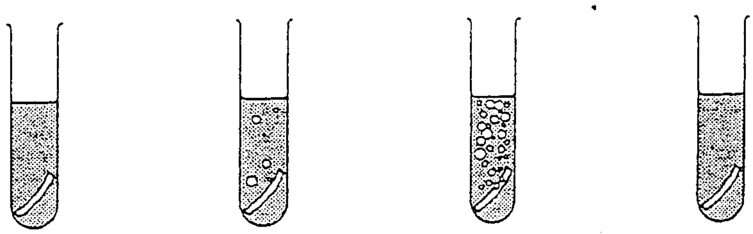
Calcium carbonate ....[1]

(iii) Name a chemical which could be used to remove the scale from the heating element.

Sulphuric acid (any acid) ....[1]

For Examiner's Use

2 Pieces of four different metals, **A**, **B**, **C** and **D** are each placed into separate test tubes containing dilute hydrochloric acid. The pieces of metal have the same area and thickness, and the acid in each tube is at room temperature. The diagram shows the four test tubes shortly after the metals have been added.



metal **A** no reaction — metal **B** slow bubbling — metal **C** fast bubbling — metal **D** no reaction

(a) Write down the name and chemical formula of the gas which is produced in the tubes containing metals **B** and **C**.

name ......hydrogen......

formula ......H_2...... [2]

(b) What conclusions can be drawn from these results about the relative reactivities of the metals **A** to **D**?

C most reactive

B 2nd most reactive

A+D both less reactive than B or C

but it is not possible to say which of A or D is the least reactive [3]

(c) When the reaction involving metal **C** finished, some metal remained.

(i) State and explain how the pH of the solution around **C** at the end of the reaction is different from that around **D**.

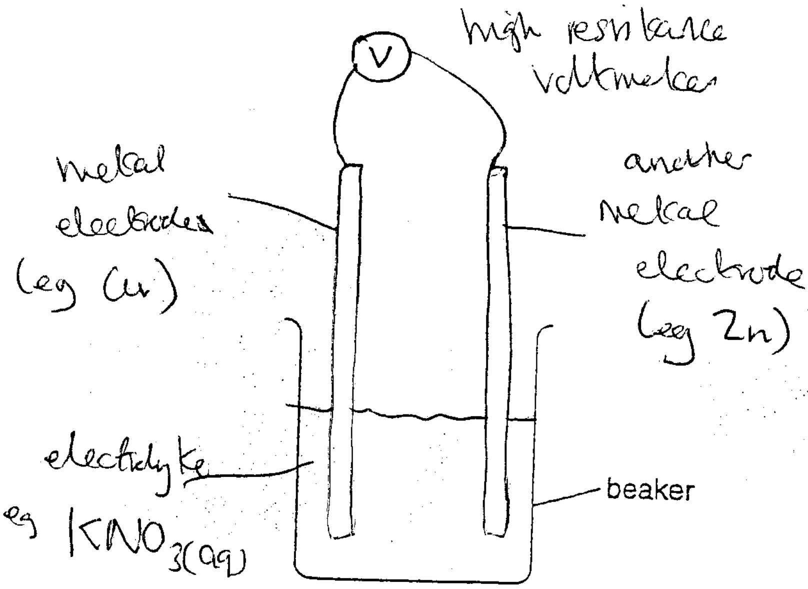
pH will be higher around C because some acid has been used up therefore pH will increase

In D, no acid has reacted, pH remains low [2]

(ii) Write the formula of an **ion** in the solution around **C**, whose concentration **decreases** during the reaction.

H^+ (or H_3O^+) [1]

(d) (i) Complete and label the diagram below to show how a simple electrical cell is set up, using two metals as electrodes, so that the voltage of the cell can be measured.



[3]

(ii) Describe and explain how experiments involving measurements of electrical cell voltages could be used to decide which metal, **A** or **D**, is the more reactive.

Set up experiment above with B or C as one electrode and measure the voltage when the other electrode is first A and then D. Since the greater the voltage, the greater the difference in reactivity, the metal (A or D) which provides the greatest voltage is the least reactive, therefore the other the more reactive of the 2

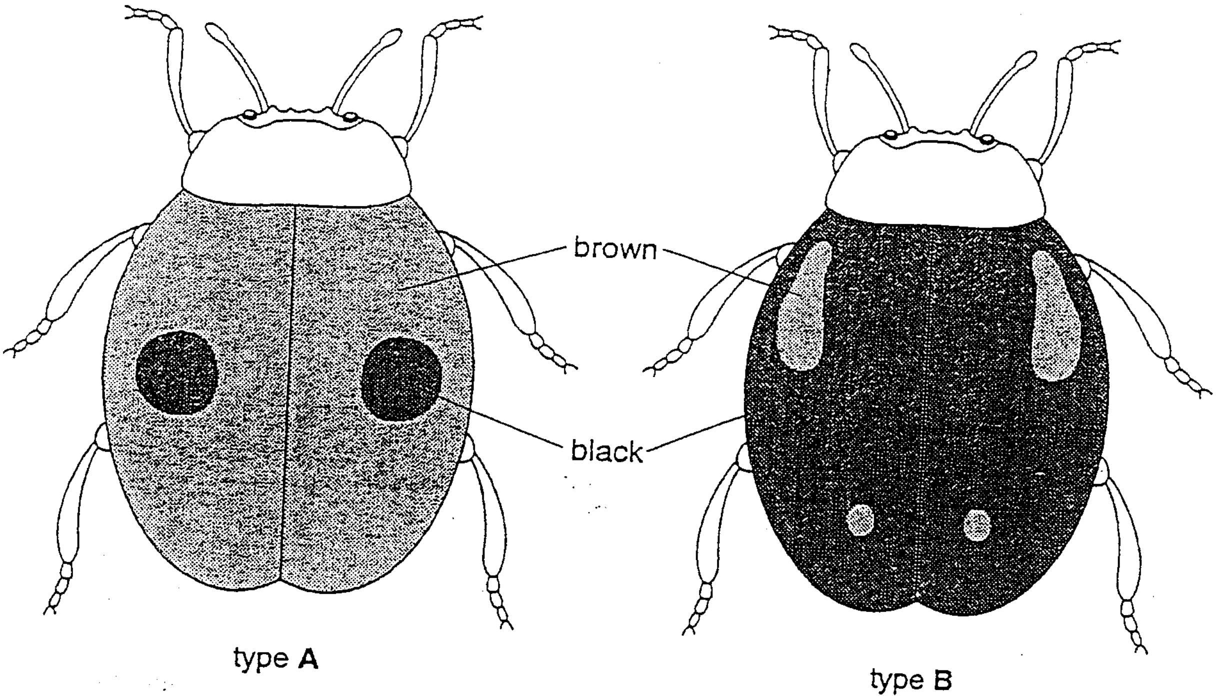
[4]

For Examiner's Use

[Turn over

For Examiner's Use

3 The diagrams show two individuals of the same species of beetle. These beetles feed on other smaller insects, and are eaten by birds. They are camouflaged to protect them from the birds.



(a) In industrial areas, type **B** is often more common than type **A**. In rural (countryside) areas, type **A** is often more common than type **B**.

Suggest how natural selection could produce this distribution of the two types of beetles.

In industrial areas A are conspicuous;
More likely to be eaten by birds;
Fewer A survive ;
A less likely to reproduce;
fewer ~~tes~~ genes/Alleles for light colour passed to next generation;

Or same argument in reverse for B [4]

For Examiner's Use

(b) The different colour patterns of the two types of beetles are controlled by a gene with two alleles, G and g.

If a homozygous type **A** beetle is crossed with a homozygous type **B** beetle, all the offspring are type **B**.

If these offspring are crossed with each other, they produce type **B** and type **A** offspring in the ratio 3:1.

(i) Explain how this information confirms the statement that the two types of beetle belong to the same species.

Reproduce to produce fertile offspring

....[1]

(ii) Draw fully labelled genetic diagrams to explain the results of the two crosses described above.

Phenotype — Light (A) — Dark (B) (1)

Genotype — gg — GG (1)

Gametes — (g) — (G) (1)

offspring genotype — (Gg) × Gg (1)

" phenotype — Dark (B)

gametes — G or g — G or g (1)

offspring Genotypes — GG, Gg, Gg, gg (1)

" phenotypes — B, B, B, A (1)

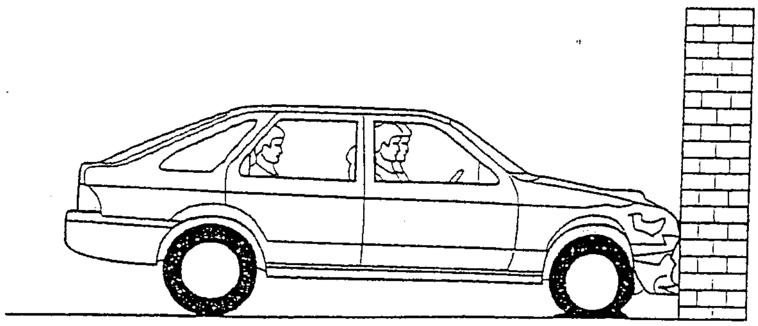
Ratio — 3 : 1 (1)

(Max 6) [6]

[Turn over

For Examiner's Use

4 A car travelling at 12 m/s collides with a strong wall which withstands the collision. The mass of the car and passengers is 1500 kg.



(a) (i) Calculate the kinetic energy of the car **before** the collision.
Show your working and state any formula which you use.

KE = ½ mv² = ½ × 1500 × 12²

= 108 000 J

[3]

(ii) What happens to this energy as a result of the collision?

• Transferred

• To heat (and sound) [2]

(b) Calculate the momentum of the car **before** the collision.
Show your working and state any formula which you use.

Mom. = mv

= 1500 × 12

= 18000 kgms⁻¹

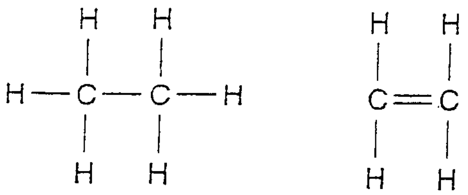
[2]

(c) Explain, in terms of kinetic energy and forces, why the wearing of seat belts usually lessens the injuries produced in a head-on car crash.

- KE is absorbed as the seat belt stretches
- As Work (Energy) = Force x distance
- The greater the stopping distance, the lower the force. [3]

For Examiner's Use

5 The graphical formulae of the gaseous hydrocarbons ethane and ethene are shown below.



(a) A sealed test tube is known to contain **either** ethane **or** ethene.

Describe a chemical test which can be used to find out which gas is in the tube.

add bromine water to the test tube of gas. If it is ethene the colour change of bromine water will be orange → colourless. Ethane will give no result. [3]

(b) Ethene is manufactured by heating alkane molecules in the presence of a catalyst.

Name this process.

cracking [1]

(c) When ethene is heated under pressure, a solid product is formed. The molecules in the solid are hydrocarbons which have a very high relative molecular mass.

Name the type of chemical reaction which produces this solid. addition polymerisation

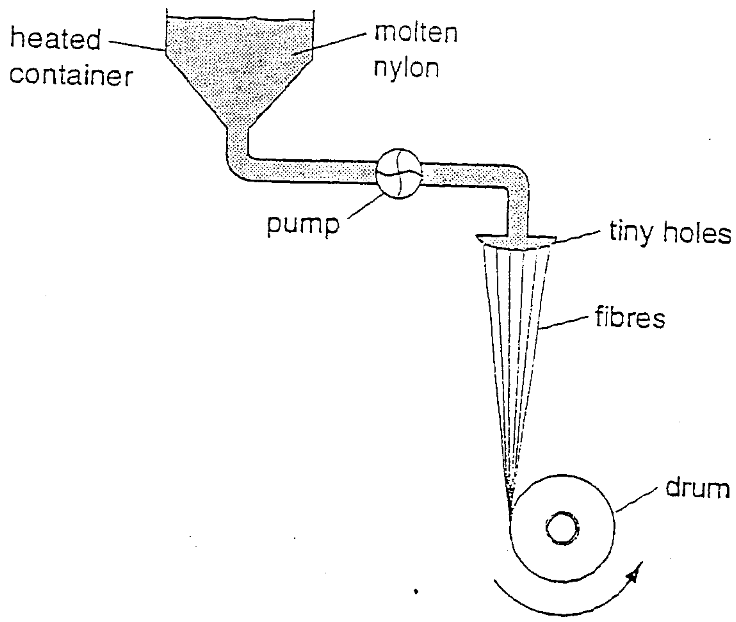
Describe what happens to the ethene molecules in the reaction.

The double bonds in ethene molecules break and then the small units join together to form long chained molecules of polyethene.

[4]

For Examiner's Use

(d) Nylon is a thermoplastic material which can be made into fibres. This is done by heating nylon so that it melts, and then pumping the molten nylon through tiny holes. The fibres cool rapidly and are wound onto a drum.

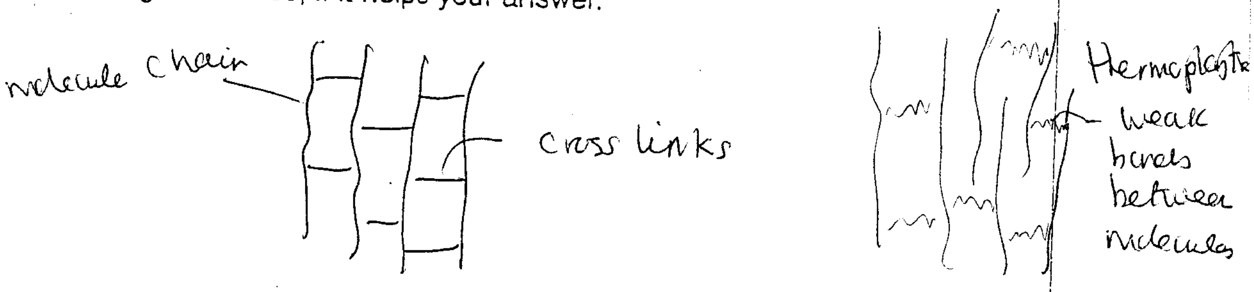


(i) Explain what is meant by the term *thermoplastic*.

softens when heated

....[1]

(ii) Explain, in terms of what happens to the molecules, why a thermoset material would be unsuitable for use in the process shown in the diagram. You may draw a sketch, showing molecules, if it helps your answer.

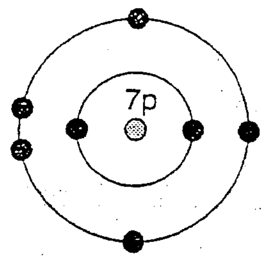


thermoset plastics have cross linking ie strong bonds which fix together the long chains. This means that thermoset plastics cannot be melted or shaped easily into long fibres unlike thermoplastics [3]
which have weak bonds between the molecules

[Turn over

For Examiner's Use

6 (a) The diagram below shows the electron arrangement and the number of protons in one atom of nitrogen.

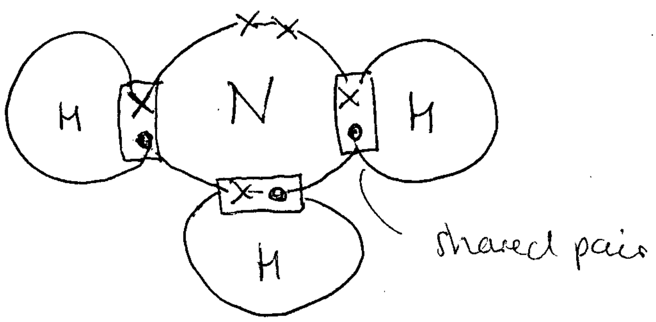


Draw a similar diagram of a phosphorus atom.

[3]

(b) Hydrogen, atomic number 1, combines with nitrogen to produce the covalent compound ammonia, NH_3.

Draw a dot and cross diagram to show the bonding in ammonia. You need only show the electrons in the outer shells.



[2]

(c) Nitrogen and hydrogen molecules can be made to react together on an iron surface to make ammonia, NH_3.

Write the balanced equation for the formation of ammonia.

$3H_2 + N_2 \rightarrow 2NH_3$ [2]

(d) Ammonia reacts with phosphoric acid to make a compound called ammonium hydrogen phosphate, which is an important fertiliser.

$$NH_3 + H_3PO_4 \rightarrow NH_4H_2PO_4$$

Calculate the mass of ammonium hydrogen phosphate which is made when 34 g of ammonia react with excess phosphoric acid. Relative atomic masses are given in the Periodic Table.

Show all your working.

from equation moles of NH_3 used = mols of $NH_4H_2PO_4$ formed

Mols of NH_3 = $\frac{mass}{Mr}$ = $\frac{34}{17}$ = 2 = mols of $NH_4H_2PO_4$ also

Mr of $NH_4H_2PO_4$ = (1×14) + (8×1) + (1×31) + (4×16)
= 14 + 8 + 31 + 64
= 117

⇒ mass = moles × Mr
= 2×117 = 234 g

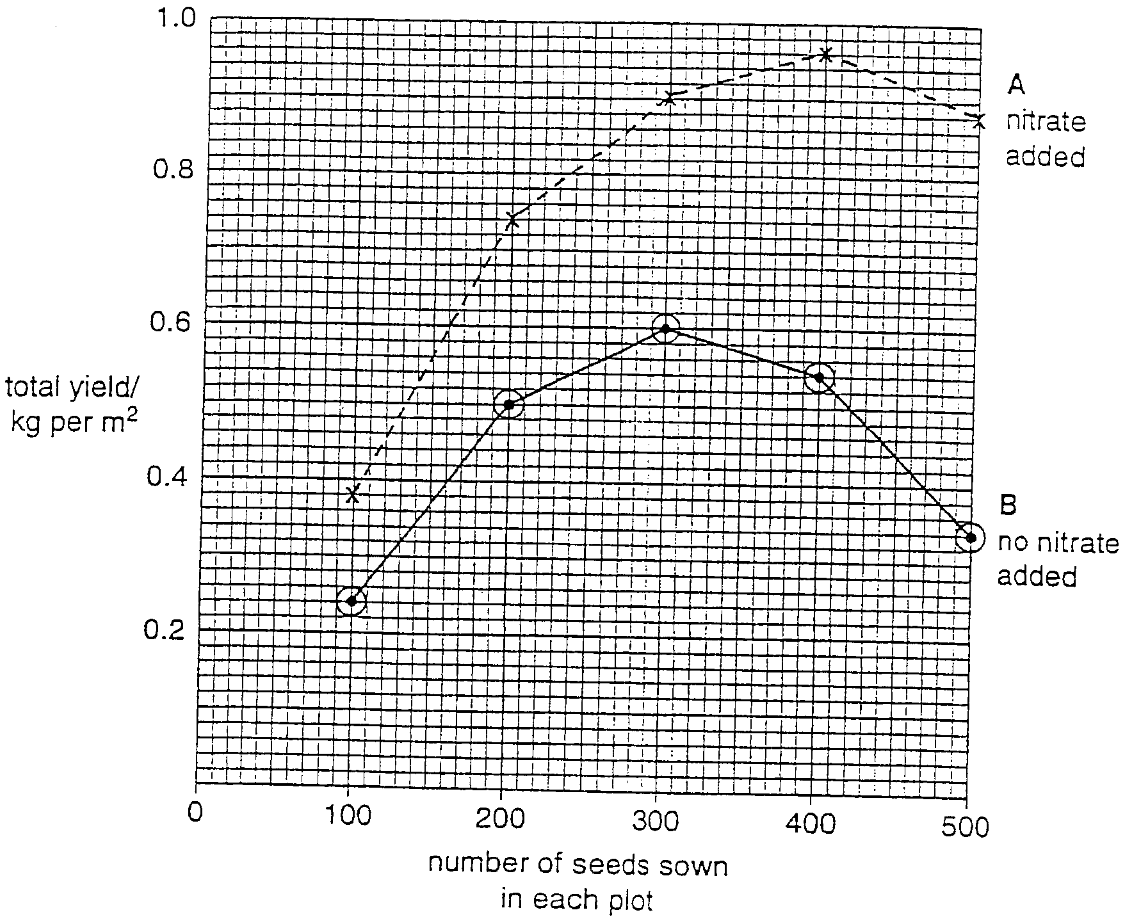
..................[4]

For Examiner's Use

7 A farmer wanted to know how to get the best yield from a variety of maize. He measured out ten plots, each 5 m x 5 m, in the same field. He added nitrate fertiliser to five plots, but not to the other five plots.

He then sowed maize seed in each of the plots. He sowed different numbers of seeds in each of the five plots with nitrate fertiliser, and also in each of the five plots with no nitrate fertiliser. All the seeds germinated.

The graph shows the yield of maize he obtained from each of the ten plots.



(a) (i) Suggest why curve **A** is above curve **B**.

More Nitrate in all plots;
More amino acids/Proteins;
Protein needed for growth;

.... [3]

(ii) Suggest why both curves rise as the number of seeds per plot increases from 100 to 300.

More than Enough Resources for all Seeds

....[1]

(iii) Suggest why both curves fall as the number of seeds per plot increases from 400 to 500.

Competition for resources;
More seeds; so fewer resources for each plant;

....[2]

(b) Next year, the farmer is going to sow maize in a field which measures 50 m x 25 m. He will add nitrate fertiliser to the field.

The mass of 100 maize seeds is approximately 50 grams.

Calculate the mass of seed the farmer should sow in the field, to get the maximum yield. Show your working.

$5 \times 5 = 25\ m^2$

$50 \times 25 = 1250\ m^2$

$\frac{1250}{25}$

$\frac{400}{100} = 4$ (1)

$4 \times 50 = 200$ (1)

200 (g) (1) ....[3]

For Examiner's Use

(c) (i) Suggest why the farmer should be careful not to apply too much nitrate fertiliser to the field.

Excess fertiliser;
Dissolves in water,
Passes into water supplies/rivers/streams
↑ in algae in water;
Algae die, bacteria multiply;
and use up all the oxygen; [3]

(ii) Suggest **one** other way in which the farmer could add nitrogen to the field.

Legumes;
Natural fertilisers [1]

For Examiner's Use

8 The pressure of the air in car tyres must be correct to give a good grip on the road surface. The correct tyre pressure partly depends on the mass of the car.

For a particular car, the correct tyre pressures are:

	pressure/10^5 N per m^2	
	cold tyres	hot tyres
front tyres	2.0	2.3
rear tyres (unloaded)	2.1	2.4
rear tyres (loaded)	2.3	2.6

(a) Use the ideas of the kinetic theory to explain why adding more air to a tyre gives it a higher pressure.

- There are more molecules in the tyre
- Therefore more collisions per second.

[2]

(b) Tyres become warmer during long journeys. Use the ideas of the kinetic theory to explain why this will result in an increase in tyre pressure.

- Molecules move faster at a higher temp.
- Therefore more (and harder) collisions per second

[2]

(c) At the start of a journey, the temperature of the front tyres was 20 °C (293 K).

Use the figures in the table to calculate the temperature in Kelvins which the front tyres might reach after a long journey.
Explain your working and state any formula which you use.

$\frac{P_2}{P_1} = \frac{T_2}{T_1}$ $\quad T_2 = \frac{P_2}{P_1} \times T_1 = \frac{2.3}{2.0} \times 293$

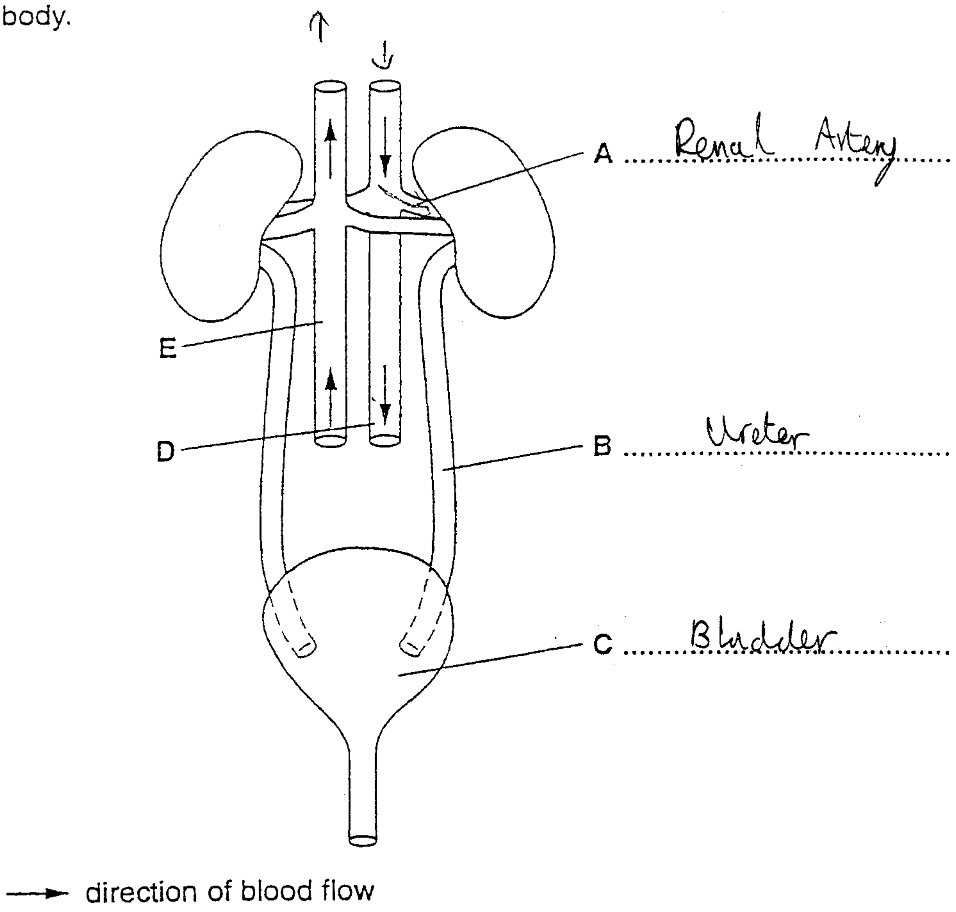
(assumes constant volume) $= 337$ K

[3]

[Turn over

For Examiner's Use

9 The diagram shows the kidneys and some of the structures associated with them in the human body.



(a) On the diagram, label structures **A**, **B** and **C**. [3]

(b) State **two** ways in which the structure of blood vessel **D** differs from the structure of blood vessel **E**.

1. D has thicker walls than E; D has more elastic fibres than E;

2. E has valves, D does not have valves; E has a wider diameter lumen; [2]

For Examiner's Use

(c) (i) Outline how the kidneys remove nitrogenous waste products from the body.

Blood enters the Kidney containing nitrogenous waste/urea
(Fluid part) Blood is filtered/ forced into space inside capsule;
Fluid Contains Urea/nitrogenous waste;
Urea is passed out in the urine;

[3]

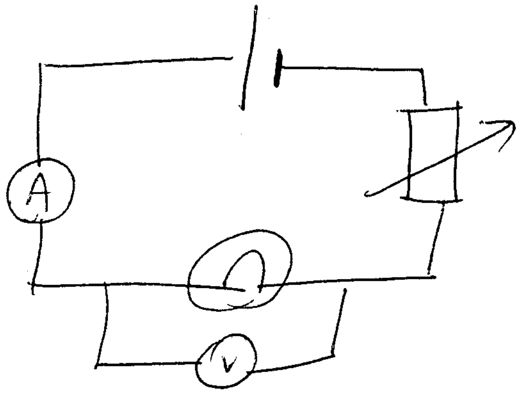
(ii) Outline how the kidneys help to regulate the amount of water in the blood.

Water is reabsorbed back into blood;
Across collecting duct walls;
If Blood dilute less water is reabsorbed
If Blood is concentrated More water is reabsorbed;

[3]

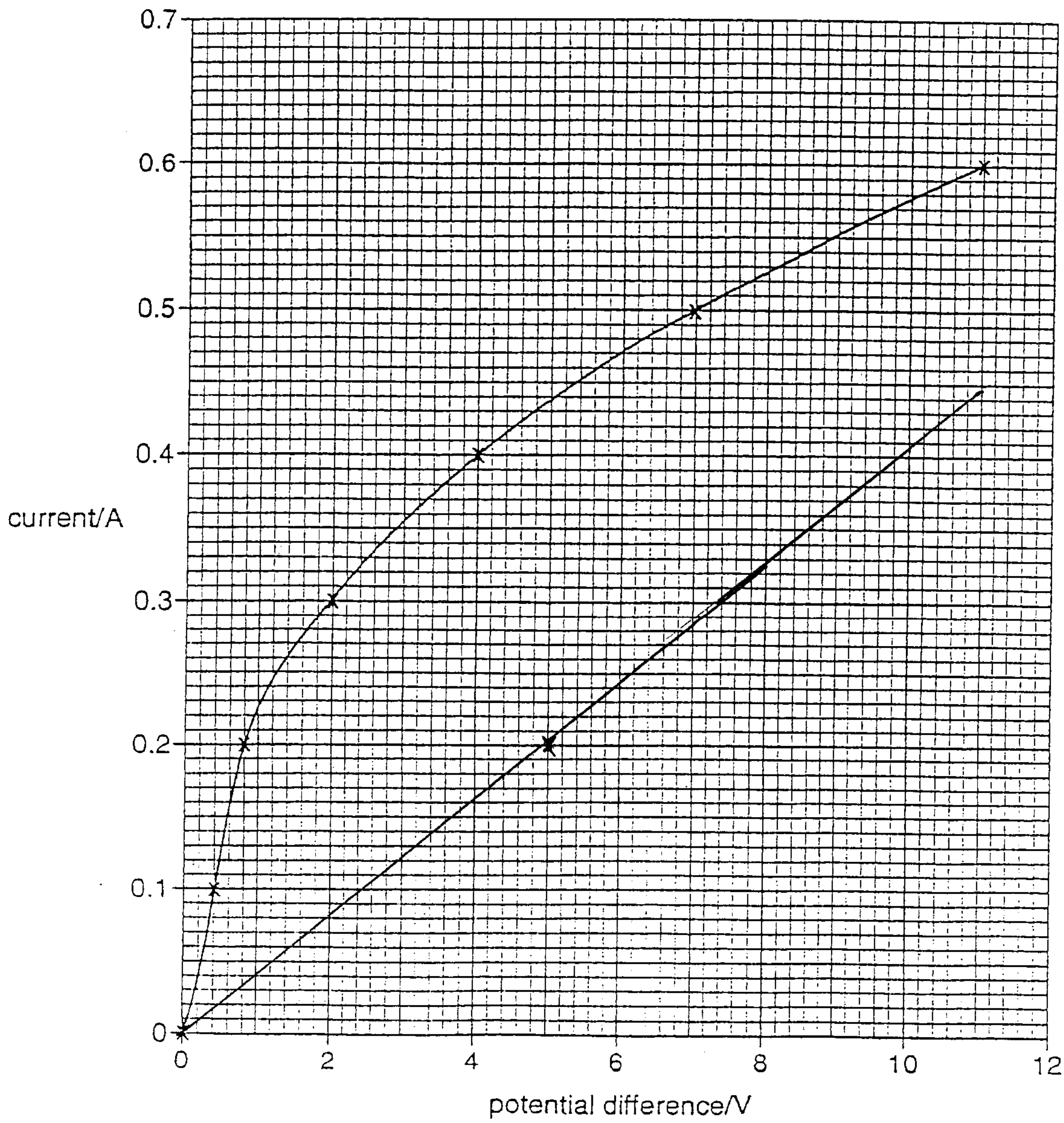
10 A student investigated the relationship between the potential difference across a lamp and the current passing through it.

(a) Draw a suitable circuit for this investigation.



[3]

The graph shows the results.



For Examiner Use

(b) From the graph, the student concluded that the relationship did not correspond to Ohm's law.

(i) Explain why the relationship between potential difference and current for a lamp does not correspond to Ohm's law.

- Ohm's Law not obeyed if resistance changes
- The resistance of the lamp increases as it gets hotter

[2]

(ii) On the graph, sketch a line to show the results you would expect if a 25 Ω resistor was used instead of the lamp. [1]

(c) Calculate the resistance of the **lamp** when the current passing through it was 0.3 A. Show your working and state any formula which you use.

$$R = \frac{V}{I} = \frac{2}{0.3} = 6.7\,\Omega$$

[2]

(d) Calculate the power used by the lamp when a potential difference of 2 V was applied. Show your working and state any formula which you use.

$$P = VI = 2 \times 0.3 = 0.6\,W$$

[2]

DATA SHEET
The Periodic Table of the Elements

I	II											III	IV	V	VI	VII	0
							1 H Hydrogen 1										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 †															

*58-71 Lanthanoid series
†90-103 Actinoid 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
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.)