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

Monday **24 MAY 1999** Afternoon 2 hours

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

Bio ✓
Chem —
Phys ✓

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 20.
You may use a calculator.

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

This paper consists of 20 printed pages.

[Turn over

For Examiner's Use

1 The molecular formulae of five compounds are shown below.

ethanol	C_2H_6O
glucose	$C_6H_{12}O_6$
glycine	$C_2H_5O_2N$
propane	C_3H_8
propene	C_3H_6

(a) State which **one** of the compounds in the table could be an amino acid.

Give a reason for your choice.

compound glycine

reason only one which contains nitrogen

nitrogen present in amino acids [2]

(b) Describe how bromine solution can be used to find out whether a flask contains propene or propane.

add bromine solution to flask and shake.

bromine solution is discoloured (orange → colourless)

only if propene is present (because propene is an unsaturated hydrocarbon) [2]

(c) At room temperature (20 °C), propene is a colourless gas. When propene is heated under pressure in the presence of a catalyst, the only product is a white solid. The solid contains molecules of the compound polypropene which is used to make artificial fibres and ropes.

(i) Name the **type** of chemical reaction which produces polypropene from propene.

addition (1) polymerisation (1) [2]

(ii) Suggest a reason why, at 20 °C, polypropene is a solid but propene is a gas.

propene is made up from small molecules

polypropene is made up from long chained (1) molecules with strong intermolecular (1) bonds

[2]

For Examiner's Use

(d) Ethanol can be produced from glucose by the action of yeast, in a process called fermentation.

The equation below shows what happens during fermentation.

$$C_6H_{12}O_6 \rightarrow 2C_2H_6O + 2CO_2$$

In a fermentation experiment, yeast was added to 1.0 dm^3 of an aqueous solution of glucose whose concentration was 5.0 mol/dm^3.

After one week 69 g of ethanol had been formed.

(i) Calculate the mass of 1 mole of ethanol. (molar mass)

Show your working.

C_2H_6O formula of ethanol

$(2 \times 12) + (6 \times 1) + (1 \times 16)$

$= 24 + 6 + 16$

$= 46\,g$

.....[2]

(ii) Calculate the number of moles of ethanol which had been formed during this fermentation experiment.

Show your working.

$$\text{moles} = \frac{\text{mass}}{\text{molar mass}}$$

$$= \frac{69}{46} = 1.5 \quad (1)$$

(1)

.....[2]

(iii) State the number of moles of glucose in the solution at the **start** of the experiment.

~~0.75~~ 5

.....[1]

(iv) Calculate the number of moles of glucose which have reacted during the experiment.

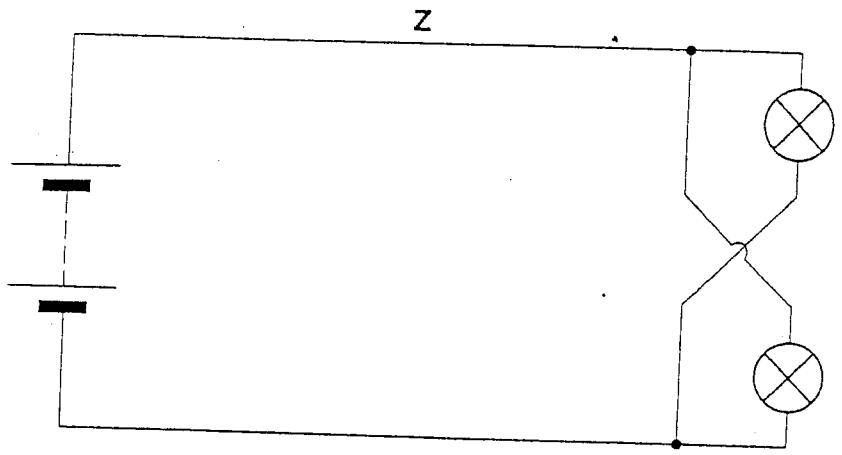
Show your working.

from equation, the moles of glucose = half moles of ethanol formed

$= \frac{1.5}{2} = 0.75$

.....[2]

2 The circuit diagram shows a parallel circuit used to supply electrical energy to two identical headlamp bulbs in a car.



The current through the filament of one headlamp is 3.0 A. The potential difference across each of the headlamps is 12 V.

(a) Calculate the resistance of the headlamp filament whilst in use.

Show your working and state any formula which you use.

$R = \frac{V}{I} = \frac{12}{3} = 4\,\Omega$

[2]

(b) What is the effective resistance of the two headlamps in parallel?

Show your working and state any formula which you use.

$\frac{1}{R} = \frac{1}{4} + \frac{1}{4} = \frac{1}{2}$

$R = 2\,\Omega$

[3]

For Examiner's Use

(c) Calculate the power supplied to each headlamp.

Show your working and state any formula which you use.

$P = VI = 12 \times 3 = 36\,W$

[2]

(d) What is the current flowing at point **Z**?

Explain your answer.

- 6.0A
- Total current in a parallel circuit is the sum of the currents in the branches [2]

(e) Explain why the bulbs are connected in parallel and not in series.

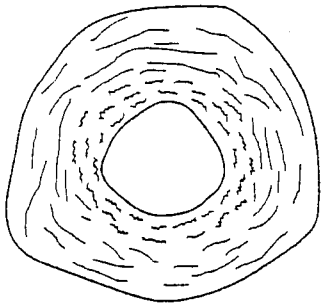
- In series they would be too dim

OR

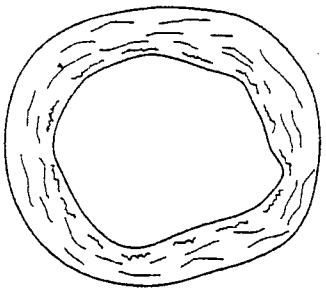
- In series if one failed both go out [1]

For Examiner's Use

3 The diagrams show transverse sections of an artery and a vein.



artery



vein

(a) State **two** differences, visible in the diagrams, between the structure of the artery and the vein. For each difference, explain how this relates to their functions.

1st difference And Vein has a wider lumen;

how this relates to their functions: Blood in vein is under low pressure; wider lumen gives ~~it~~ less resistance to blood flow;

2nd difference Artery has thicker walls;

how this relates to their functions: Artery has to withand Blood of hyher pressure; When ventricles contract;

Arteries have more elastic fibres; When ventricles contract; Elastic fibres stretch; and then recoil; [6]

For Examiner's Use

(b) The blood in both the artery and vein contains red blood cells. The red blood cells contain a protein called haemoglobin.

(i) State the function of haemoglobin.

Carries O_2 [1]

(ii) Name **two** other proteins found in the human body, and outline the function of each. Any enzyme.

name e.g. Amylase

function Catalyses breakdown of starch to glucose/maltose.

name Antibodies;

function ~~Fight~~/ destroy Microorganisms

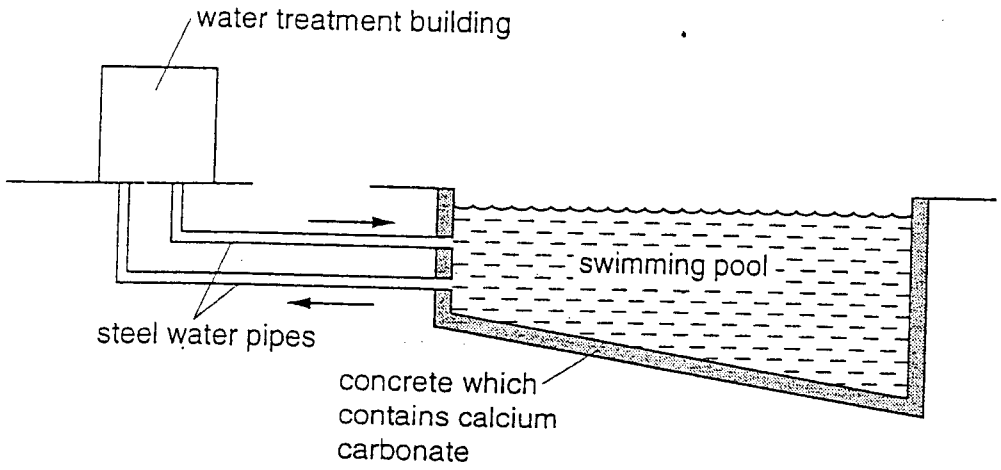
[4]

Fibrin;

Blood clot;

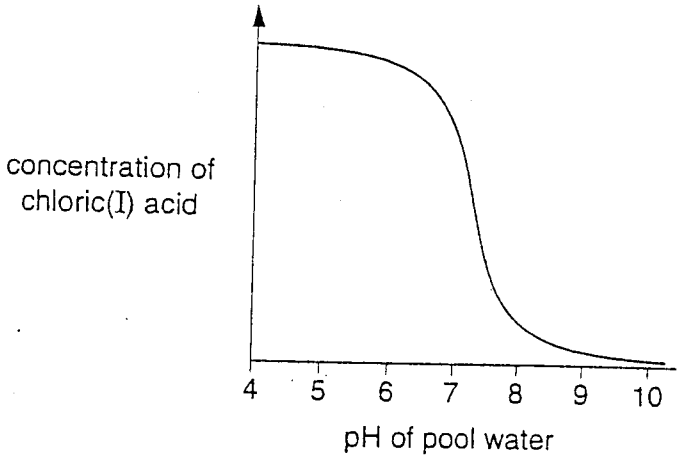
(Anything sensible)

4 The diagram shows a swimming pool. Water from the pool is pumped through steel pipes to the water treatment building where chlorine compounds are added to kill bacteria.



(a) The chlorine compound which is most effective in killing bacteria is chloric(I) acid, HOCL

The graph shows how the concentration of chloric(I) acid varies with the pH of the pool water.



(i) Using the information from the graph, state the pH range which would be most effective for killing bacteria in the pool.

Explain your answer briefly.

4–6

concentration of chloric(I) acid is highest

[2]

For Examiner's Use

(ii) The pH of the pool water is normally kept at a value of 7.4

Suggest **two** reasons why the pool water is kept at this pH rather than within the range you have suggested in (i).

1. If the pool water is too acidic it could react with the steel pipes or the concrete containing calcium carbonate

2. At pH 7.4 the concentration of the acid is still high enough to kill bacteria [2]

(b) If the water in the pool becomes too acidic sodium carbonate is added.

(i) Sodium carbonate, Na_2CO_3, contains sodium ions, Na^+.

State the formula and electrical charge of the carbonate ion.

Show your reasoning.

2 Na^+ present therefore CO_3^{2-}

So that charges balance and add up to zero

$2\times(+1) + (-2) = 0$

.....[2]

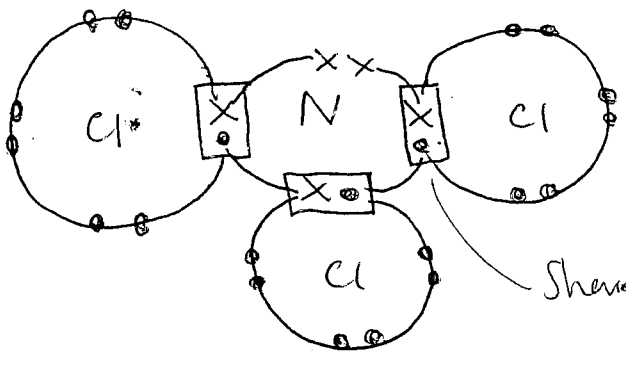
(ii) Write the formula of the **ion** whose concentration in the pool water **decreases** when sodium carbonate is added.

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

(c) When large numbers of people are using the pool, the concentration of nitrogen compounds in the water increases. These compounds react with chloric(I) acid.

(i) One substance which can form when chloric(I) acid reacts is nitrogen trichloride, NCl_3, which causes eyes to become very sore.

Draw a diagram of a nitrogen trichloride molecule to show how the outer electrons in each atom are arranged.



[3]

For Examiner's Use

(ii) Suggest and explain **one** water treatment which may be needed to control the water quality in the pool when large numbers of people are swimming.

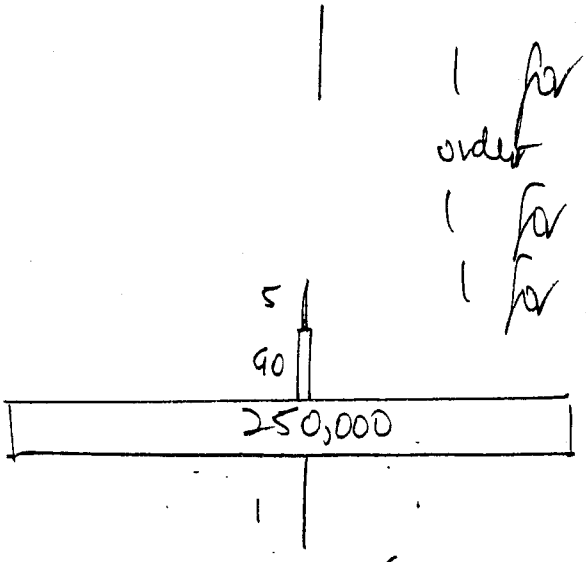
The water should be filtered regularly to remove toxic substances, although new amounts of chlorine acid should be added to maintain safety (prevent bacteria build up) [2]

5 Mopane trees grow in southern Africa. Some ecologists collected all the organisms living on a small mopane tree. They identified the organisms, and determined which trophic level each of them belonged to. Their results are shown in the table.

trophic level	*number of organisms*
producers	1
primary consumers	250 000
secondary consumers	90
tertiary consumers	5

(a) Sketch the shape of a pyramid of **biomass** to represent the mopane tree ecosystem.

Label the parts of the pyramid you have drawn.



1 for Correct order
1 for Labels
1 for Shape.

(Does not have to be to scale)

[3]

For Examiner's Use

(b) Suggest reasons for the shape of the pyramid you drew in (a).

Tree is a large organism;
Supports a large number of organisms;
Fewer 2° than 1° Consumers (3° than 2°)
Because energy is lost from food chain;
Through respiration; [3]

The most abundant primary consumers on the mopane tree were caterpillars known as mopane worms. These caterpillars are roasted or dried and then eaten by people in many parts of southern Africa, as they are an excellent source of protein.

(c) State **two** factors which might limit the growth of the population of mopane worms.

1. Eaten by man
2. Not enough food source/ mopane tree. [2]

(d) Outline the processes by which protein from a mopane worm would be digested and absorbed, after being eaten by a person.

Protein Digested by proteases;
In stomach/ small intestine;
Converted into amino Acids;
absorbed into blood in small intestine;
[4]

For Examiner's Use

6 (a) Explain how a microphone can change sounds into electrical signals.

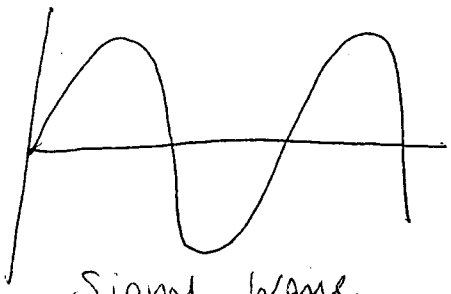
- Microphone has a coil within a magnetic field
- Sound causes this coil to vibrate
- Alternating voltage signal is induced in the coil (electromagnetic induction)

[3]

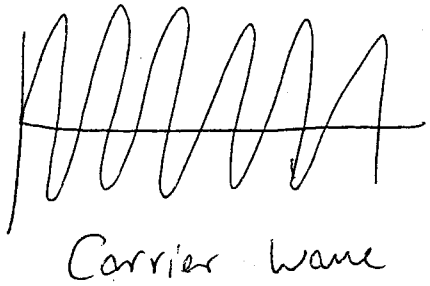
(b) Radio waves are used to carry information. To do this a radio carrier wave needs to be modulated.

Explain briefly how the carrier wave changes when it is modulated.

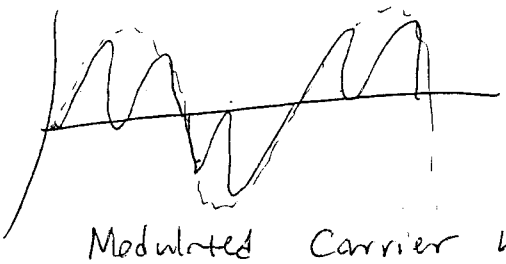
You may draw diagrams if it helps your answer.



Signal wave



Carrier wave



Modulated Carrier wave.

- The amplitude of the Carrier wave is changed (modulated) by the signal wave.
- This is called amplitude modulation [3]

(OR Could show frequency modulation)

For Examiner's Use

(c) The radio waves may be transmitted using satellites. Explain why it is possible for satellites to orbit the Earth without falling to the surface.

Satellites have a tangential velocity so that the Earth's surface falls away below them as they fall towards the surface (due to curvature of earth) [2]

(d) Television signals are also radio waves. These are received by a television aerial.

(i) Suggest why television aerials are usually placed high up on buildings, usually on the roof.

Better reception: radio waves can be blocked [1]

(ii) Television sets contain microprocessors. What is a microprocessor?

A Computer. [1]

(iii) In a television set there is a tube which contains a heated wire. The picture on the screen is produced when emissions from this wire hit the screen.

State what is emitted by the heated wire.

Electrons [1]

For Examiner's Use

7 (a) A tower is 400 m high. A visitor drops his binoculars from the top of the tower.

(i) Use the formula $s = \frac{1}{2}at^2$ to calculate how long it will take the binoculars to hit the ground.
(The acceleration due to gravity is 9.8 m/s^2.)

$t = \sqrt{\frac{25}{9}} = \sqrt{\frac{2 \times 400}{9.8}} = 9.0$ sec.

[2]

(ii) The calculation in (i) ignores another force which acts on the binoculars, as they move through the air, and slows them down. Name this decelerating force.

Drag / air resistance [1]

(iii) The visitor shouts a warning to the people below. How soon after dropping the binoculars must he shout if the people are to hear the warning before the binoculars hit them?

Assume that sound travels at 330 m/s.

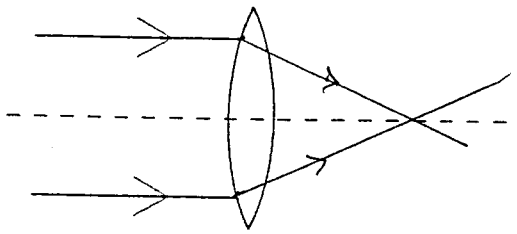
Time for sound to reach ground $= \frac{400}{330} = 1.2$ sec.

Answer $= 9.0 - 1.2 = 7.8$ sec (less than)

[2]

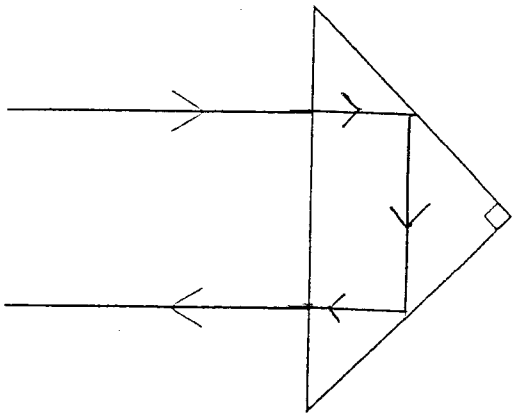
(b) Binoculars contain lenses and prisms.

(i) Complete the diagram below to show how a lens refracts light and brings it to a focus.



[1]

(ii) Prisms allow light rays to be totally internally reflected. Rays of light enter and leave the prism as shown. Complete the diagram below to show the path of the ray through the prism.



[2]

(c) (i) Red light has a wavelength of 0.6 micrometres and travels at a speed of 3×10^{14} micrometres per second.

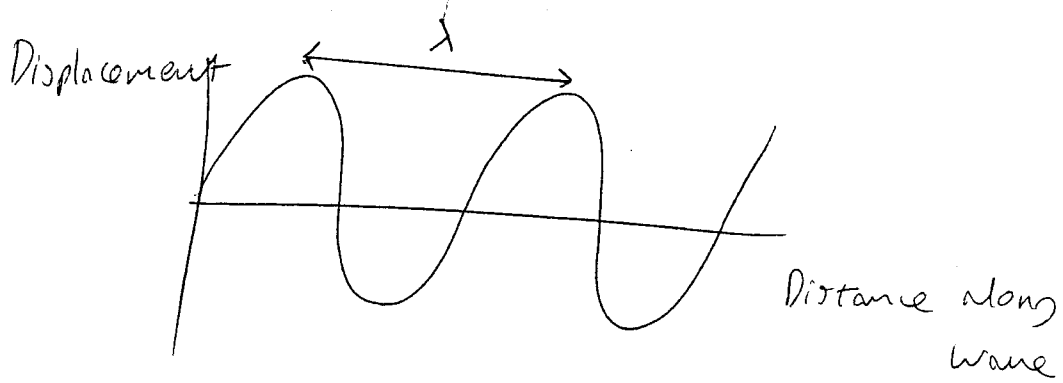
Calculate the frequency of this light.

Show your working and state any formula which you use.

$f = \frac{V}{\lambda} = \frac{3 \times 10^{14}}{0.6} = 5 \times 10^{14}$ Hz

[3]

(ii) Draw a labelled diagram to explain the meaning of the word *wavelength*.



[1]

8 Part of the reactivity series of metals is shown below.

magnesium	(most reactive)
aluminium	
zinc	
iron	
copper	(least reactive)

(a) All of the metals in the list form oxides.

(i) Name the type of chemical reaction which changes a metal into its oxide.

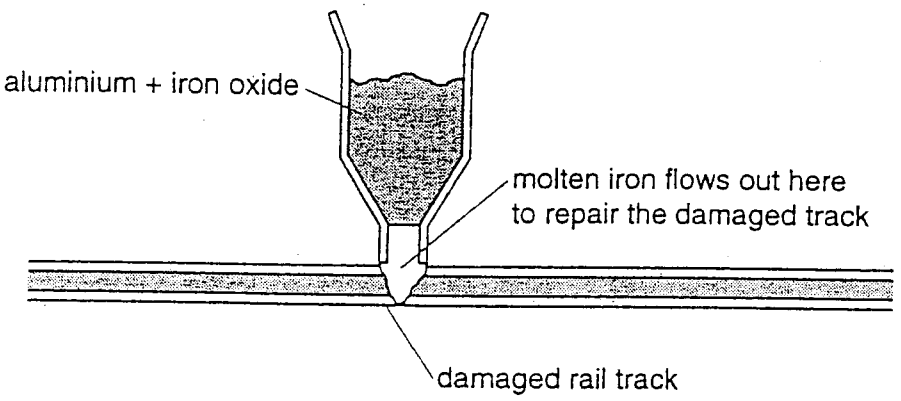
Oxidation [1]

(ii) Describe the electronic structure of a magnesium atom and how it changes when magnesium reacts with oxygen.

Mg contains 2 outer electrons which are transferred to the oxygen atom so that both atoms have complete & stable outer shells. [2]

(b) The 'thermite' reaction is used to repair damaged rail tracks.

The diagram shows a simplified version of the apparatus and the chemicals which are involved.



(i) Write a word equation for the thermite reaction.

aluminium + iron oxide → iron + aluminium oxide [1]

(ii) Suggest why this reaction produces **molten** iron.

very exothermic

[1]

For Examiner's Use

(iii) Explain why copper would **not** react to produce any iron if it were used instead of aluminium in the thermite reaction.

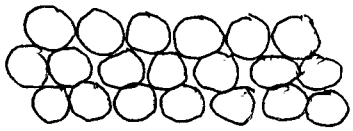
Copper is lower than Iron in reactivity series. A metal (such as aluminium) needs to be higher than Iron if it is to reduce Iron oxide.

[3]

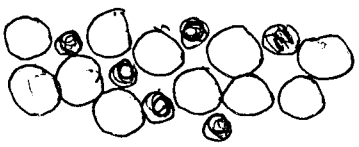
(c) Brass is an alloy made of 60% copper and 40% zinc.

(i) Use your knowledge of the structure of metals to explain why pure metals are more malleable than alloys made from them.

You may draw diagrams to help you to answer this question.



regular arrangement of metal atoms in a pure metal



regular arrangement disrupted by other atoms alloying with pure metal

pure metals are malleable because the regular arrangement of atoms allows slippage when the metal is bent or shaped. Alloying prevents slippage by disrupting the layers (smaller or larger atoms added)

[4]

(ii) Calculate the density of brass given that the density of copper is 8.9 g/cm^3 and of zinc is 7.1 g/cm^3.

$(0.6 \times 8.9) + (0.4 \times 7.1)$

$= 5.34 + 2.8$

$= 8.14 \text{ g/cm}^3$

[2]

9 Rats are serious pests in many parts of the world. A pesticide called warfarin is used to kill them.

Some rats are rapidly killed by warfarin, while others are resistant to it and are not killed. This is determined by a gene with two alleles, **R** and **r**. Rats with the genotypes **RR** and **Rr** are resistant to warfarin, while rats with the genotype **rr** are not.

However, rats with the genotypes **RR** and **Rr** need larger amounts of a particular vitamin in their diet in order to survive, than rats with the genotype **rr**. In fact, **RR** rats need so much of this vitamin that they usually die from vitamin deficiency.

(a) Does resistance to warfarin by rats show *continuous variation*, or *discontinuous variation*? Explain your answer.

Discontinuous (1)

Only 2 phenotypes (1)

.....[2]

(b) State and explain the genotype which would be most likely to enable a rat to survive and reproduce in each of the following situations.

(i) a farm where warfarin is regularly used:

genotype Rr

explanation Resistant to Warfarin, but not as deficient in Vitamin

.....[2]

(ii) a farm where warfarin has never been used:

genotype rr

explanation Does not require as much vitamin, Does not need to have resistance to warfarin

.....[2]

For Examiner's Use

(c) When warfarin was first used, in 1950, very few rats were resistant to it. By 1958, many rats were resistant to warfarin, and resistance is now very common.

Explain how this change may have happened.

Some rats in a population are resistant
Warfarin applied
Resistant rats Survive / no resistance die
Reproduce
allele for resistance passed on to
next generation

.....[4]

(d) Many pests, not only rats, have become resistant to pesticides. Pesticides may also harm other organisms. Alternative ways of controlling pests are therefore being tried.

(i) Describe **one** method of controlling a **named** pest which does **not** involve the use of a pesticide.

Biological Control,
eg. ladybird; controlling aphids

Anything

.....[2]

(ii) Outline **one disadvantage** of the method you have described, compared with the use of a pesticide.

Sensible.

ladybird May eat other organisms

.....[1]

DATA SHEET
The Periodic Table of the Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 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 †															

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

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

Key: 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.)