Cathkin High School
Chemistry **Department**

Senior Phase

NATIONAL 5
CHEMISTRY

Unit 3: Chemistry in Society

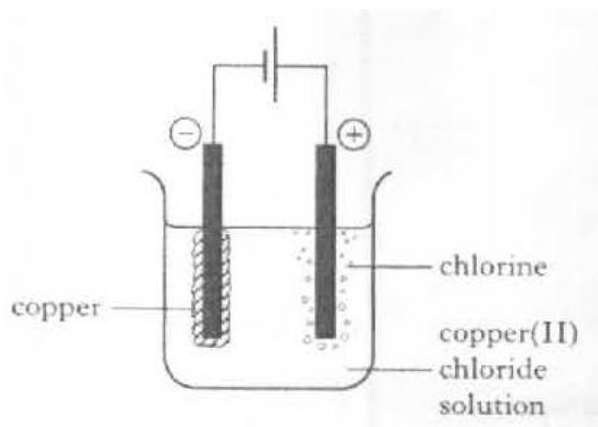# Past Paper
Homework

Metals

1. A copper (II) chloride solution was electrolysed.

Which of the following changes occurred at the negative electrode?
A Copper atoms were reduced
B Copper atoms were oxidised
C Copper ions were reduced
D Copper ions were oxidised   1

2. Which metal can be extracted from its oxide by heat alone?
A lead
B mercury
C tin
D zinc   1

3. An oil rig can be protected from corrosion by attaching pieces of magnesium to the structure. This method of protection is called
A galvanising
B electroplating
C physical protection
D sacrificial protection   1
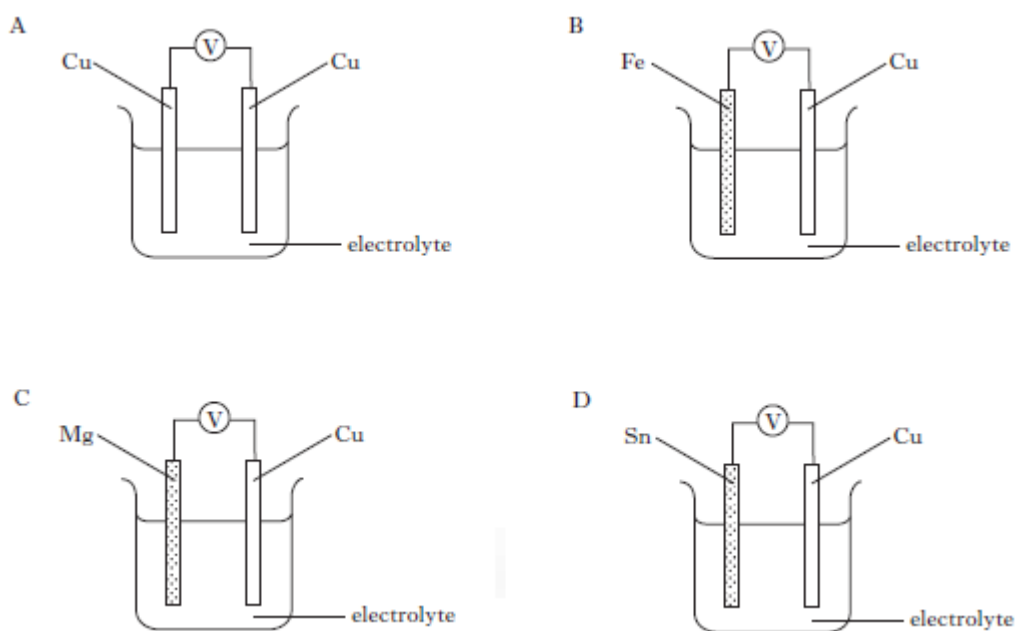
4. Which of the following solutions will react with magnesium metal?
A Magnesium chloride
B Zinc chloride
C Potassium chloride
D Sodium chloride   1

5. Which of the following cells would produce the highest voltage?
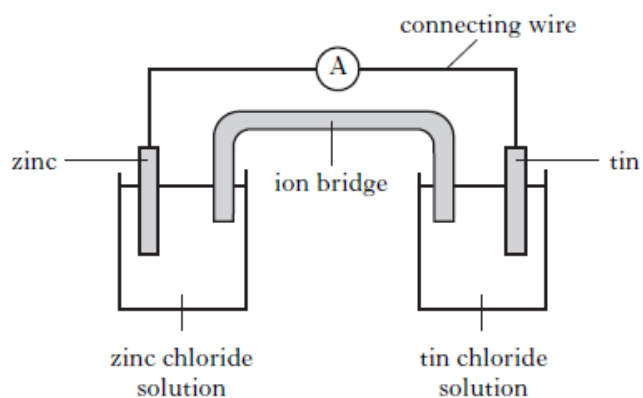   (You may wish to the data booklet to help you.)   1

A   B

Cu   V   Cu   Fe   V   Cu

electrolyte   electrolyte

C   D

Mg   V   Cu   Sn   V   Cu

electrolyte   electrolyte

6. Which ion will turn ferroxyl indicator pink?
    A Fe^{2+} (aq)
    B Fe^{3+} (aq)
    C H^+ (aq)
    D OH^- (aq)   1

7.

connecting wire

A

zinc   tin

ion bridge

zinc chloride   tin chloride
solution   solution

In the cell shown above, electrons flow through
A the solution from tin to zinc
B the solution from zinc to tin
C the connecting wire from tin to zinc
D the connecting wire from zinc to tin.   1

8.   Which of the following metals is found uncombined in the Earth's crust?
        A Aluminium
        B Iron
        C Lead
        D Silver   1

9. Which ion gives a blue colour with ferroxyl indicator?
        A $H^+(aq)$
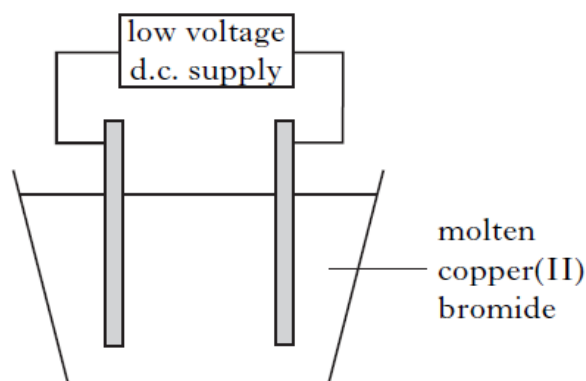   B $OH^-(aq)$
        C Fe^{2+} (aq)
        D Fe^{3+} (aq)   1

10.   Which of the following methods can give both physical and sacrificial protection to iron?
        A Painting
        B Greasing
        C Tin-plating
        D Galvanising   1

11.

During the electrolysis of molten copper(II) bromide
A copper atoms lose electrons to form copper ions
B bromine molecules gain electrons to form bromide ions
C bromide ions gain electrons to form bromine molecules
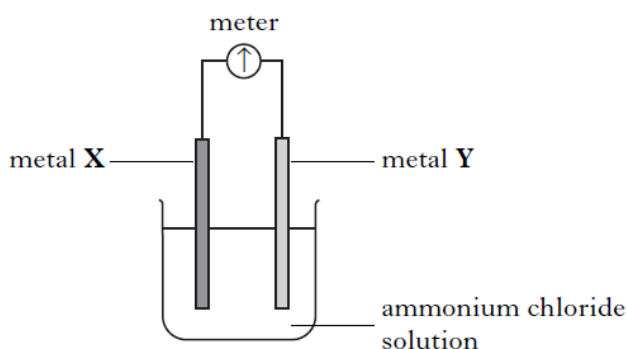D copper ions gain electrons to form copper atoms.   1

12.   The ion-electron equation
        $Ti(s) \rightarrow Ti^{2+}$ (aq) + $2e^-$
        represents the
        A reduction of titanium atoms
        B reduction of titanium ions
        C oxidation of titanium atoms
        D oxidation of titanium ions.   1

13.	Which pair of metals, when connected in a cell, would give the highest voltage and a flow of electrons from X to Y?
(You may wish to use page 7 of the data booklet to help you.)	1

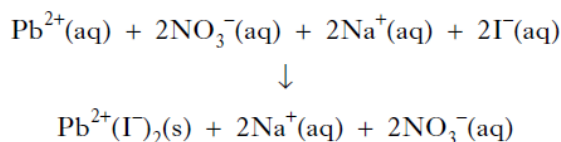|	Metal X	Metal Y
A	magnesium	copper
B	copper	magnesium
C	zinc	tin
D	tin	zinc

14.	The following statements relate to four different metals, P, Q, R and S.
Metal P displaces metal Q from a solution containing ions of Q.
In a cell, electrons flow from metal S to metal P.
Metal R is the only metal which can be obtained from its ore by heat alone.
The order of reactivity of the metals, starting with the most reactive is
A S, P, Q, R
B R, Q, P, S
C R, S, Q, P
D S, Q, P, R.	1

15.	The equation for the reaction between lead(II) nitrate and sodium iodide is:

$$Pb^{2+}(aq) + 2NO_3^-(aq) + 2Na^+(aq) + 2I^-(aq)$$
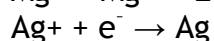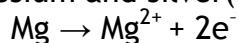
$$\downarrow$$

$$Pb^{2+}(I^-)_2(s) + 2Na^+(aq) + 2NO_3^-(aq)$$
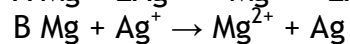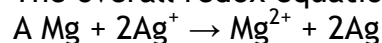
The spectator ions present in this reaction are
A $Na^+(aq)$ and $NO_3^-(aq)$
B $Na^+(aq)$ and $I^-(aq)$
C $Pb^{2+}(aq)$ and $NO_3^-(aq)$
D $Pb^{2+}(aq)$ and $I^-(aq)$.	1

5

16. The ion-electron equation for the oxidation and reduction steps in the reaction between magnesium and silver(I) ions are:

$$Mg \rightarrow Mg^{2+} + 2e^-$$
$$Ag+ + e^- \rightarrow Ag$$

The overall redox equation is

A $Mg + 2Ag^+ \rightarrow Mg^{2+} + 2Ag$

B $Mg + Ag^+ \rightarrow Mg^{2+} + Ag$

C $Mg + Ag^+ + e^- \rightarrow Mg^{2+} + Ag + 2e^-$

D $Mg + 2Ag \rightarrow Mg^{2+} + 2Ag^+$.   1

17. Aluminium can be extracted from aluminium oxide by

A heating alone

B heating with carbon

C heating with carbon monoxide
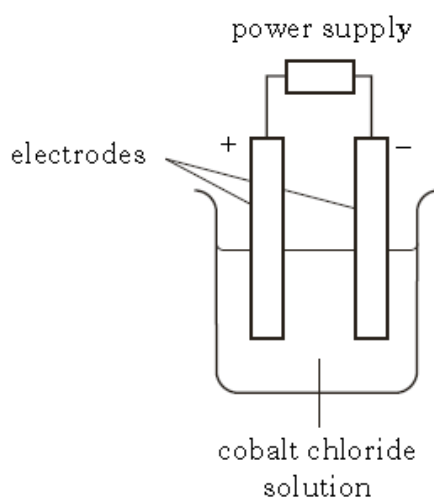
D electrolysis.   1

18. Tin and its compounds have many uses.

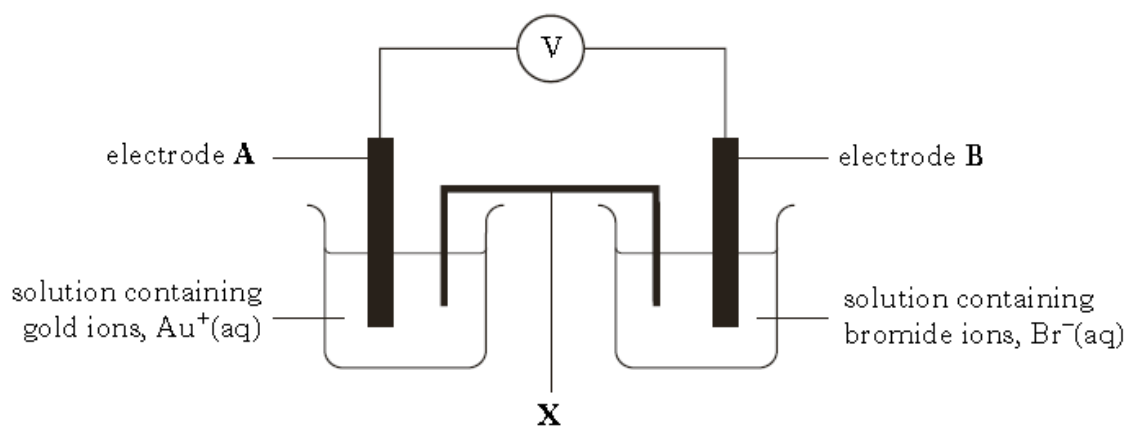Why do metals such as tin conduct electricity?   1

19. A student set up the following experiment to electrolyse cobalt chloride solution.
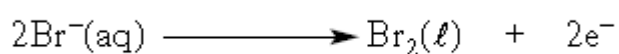

(a) What type of power supply must be used to electrolyse cobalt chloride solution?   1

(b) Describe what would be seen at the positive electrode.
You may wish to use the data booklet to help you.   1
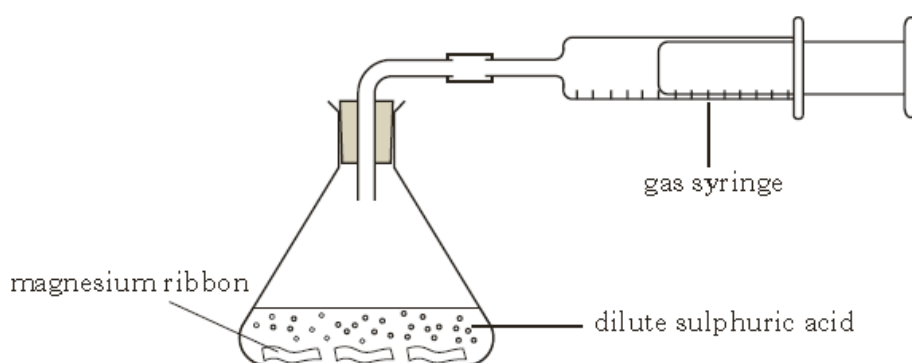
6

20.   A technician set up the following cell.

The reaction taking place at electrode B is:

$$2Br^-(aq) \longrightarrow Br_2(\ell) \ + \ 2e^-$$

(a)   On the diagram, clearly mark the path and direction of electron flow.   1

(b)   Write the ion-electron equation for the reaction taking place at electrode A.
       You may wish to use the data booklet to help you.   1

(c)   Name the piece of apparatus labelled X.   1

21.   Hydrogen gas is produced when magnesium reacts with dilute sulphuric acid.

The equation for the reaction is:

$$Mg(s) \ + \ H_2SO_4(aq) \longrightarrow MgSO_4(aq) \ + \ H_2(g)$$

Give the formula for the salt in the above equation.   1

22. Titanium is an important metal used in aircraft manufacture.
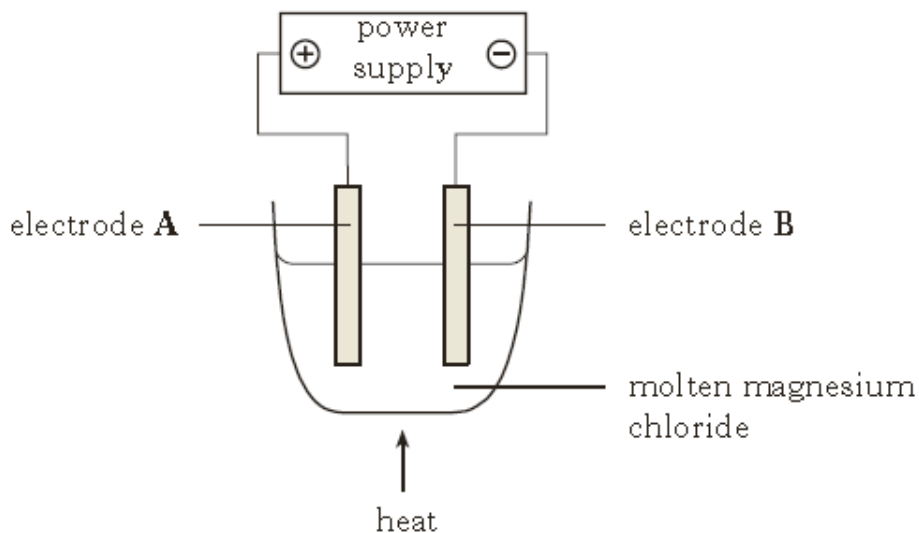
(a) Titanium can be produced from titanium chloride as shown.

$$2Mg(s) + TiCl_4(\ell) \longrightarrow 2MgCl_2(s) + Ti(s)$$

Name the type of chemical reaction represented by the equation.   1

(b) The magnesium chloride produced can be electrolysed as shown.

(i) At which electrode would magnesium be produced, A or B?   1

(ii) Write the ion-electron equation for the formation of chlorine.
You may wish to use the data booklet to help you.   1

23. Mercury can be extracted from the ore cinnabar, HgS.
Calculate the percentage by mass of mercury in cinnabar.   2

24. Metals can be extracted from metal compounds by heat alone, heating with carbon
or by electrolysis.
Name the type of chemical reaction which takes place when a metal is extracted
from its compound.   1

25. The composition of a 250g magnet is shown.
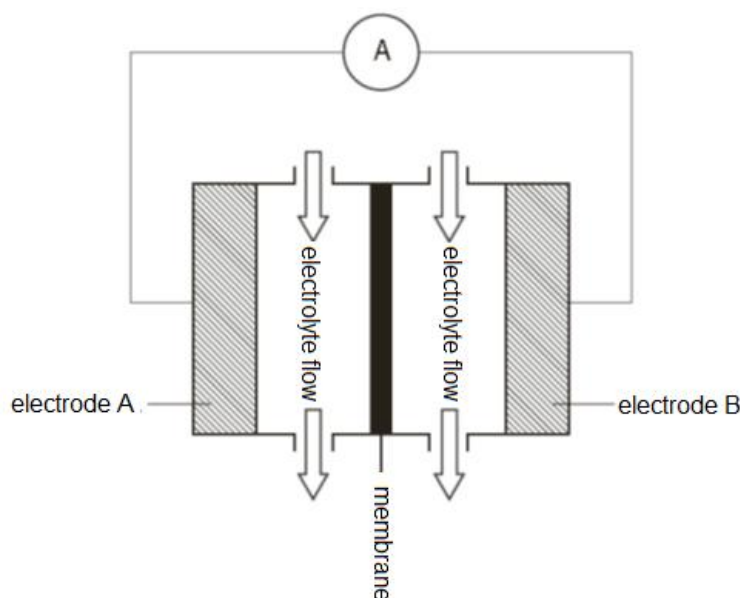
Metal	aluminium	nickel	cobalt	copper	titanium	iron
% by mass	10	25	20	4	1	40

Calculate the mass, in grams, of aluminium in the magnet.
Show your working clearly.   1

26. In Australia flow cells are used to store the energy from solar cells.

(a) The reaction taking place at electrode A when the cell is providing electricity is:
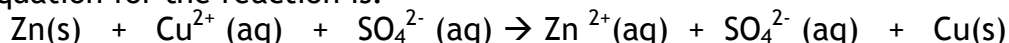$Zn \rightarrow Zn^{2+} + 2e^-$

Name the type of chemical reaction taking place at electrode A.   1

(b) Sketch the diagram and mark on it the path and direction of electron flow.   1

(c) Name the non-metal that conducts electricity, which could be used as an electrode.   1

27. Zinc displaces copper from copper(II) sulphate solution.
The equation for the reaction is:
$Zn(s) + Cu^{2+} (aq) + SO_4^{2-} (aq) \rightarrow Zn^{2+}(aq) + SO_4^{2-} (aq) + Cu(s)$
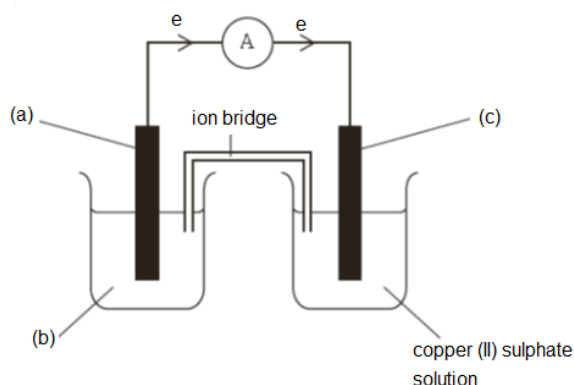
(a) Give the symbol for the spectator ion in the above equation.   1

(b) Write the ion-electron equation for the oxidation step in this reaction.
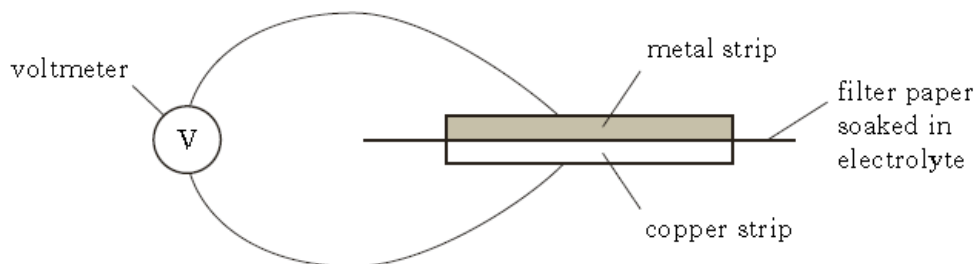You may wish to use the data booklet to help you.   1

(c) The reaction can also be carried out in a cell.

(i) Complete the three labels (a), (b) and (c) on the diagram.   1

(ii) What is the purpose of the ion bridge?   1

28. The voltage obtained when different pairs of metal strips are connected in a cell varies and this leads to the electrochemical series.
Using the apparatus below, a student investigated the electrochemical series. Copper and four other metal strips were used in this investigation.
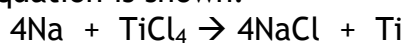

The results are shown.

Metal strip	Voltage (V)	Direction of electron flow
1	0·6	metal 1 to copper
2	0·2	copper to metal 2
3	0·9	metal 3 to copper
4	0·1	copper to metal 4

(a) Which of the metals used is highest in the electrochemical series?   1

(b) Which two of the metals used would produce the highest voltage when connected in a cell?   1

(c) What would be the reading on the voltmeter if both strips of metal were copper?   1

29. Titanium metal is used to make dental braces.

Titanium is extracted from its ore in the Kroll process. One step in this process involves the displacement of titanium chloride by sodium metal.
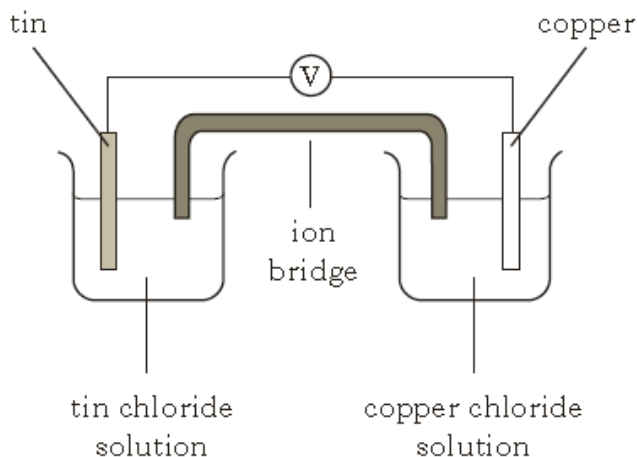The equation is shown.

4Na + TiCl$_4$ → 4NaCl + Ti

During the displacement, sodium atoms, Na, form sodium ions, Na+.
Write the ion-electron equation for this change.   1

30.   Copper is a good conductor of electricity because
       A the atoms are free to vibrate
       B the atoms are in close contact
       C the atoms have the electron arrangement 2, 8, 18, 1
       D electrons can move readily from one atom to the next.   1

31.   In the cell shown electrons flow through

       A the solution from copper to tin
       B the solution from tin to copper
       C the wires from copper to tin
       D the wires from tin to copper.   1

32.   Which of the following metals, when linked to zinc, would give the highest cell voltage?
       (You may wish to use the data booklet to help you.)

       A Copper
       B Iron
       C Magnesium
       D Tin   1

33.   When a metal element reacts to form a compound the metal is
       A displaced
       B oxidised
       C precipitated
       D reduced.   1

34. Anglesite is an ore containing lead(II) sulphate, $PbSO_4$.

   (a) Calculate the percentage by mass of lead in anglesite.   2

   (b) Most metals are found combined in the Earth's crust and have to be extracted from their ores. Identify metal Y and metal Z in the table below.
   Choose from **lead** and **aluminium**
   You may wish to use the data booklet to help you.   1

Metal	Method of extraction
Y	electrolysis of molten compound
Z	using heat and carbon

   (c) Metal **X** can be extracted from its ore by heat alone.
   What does this indicate about the reactivity of X compared to both lead and aluminium?   1

   (d) When a metal is extracted from its ore, metal ions are changed to metal atoms.
   Name this type of chemical reaction.   1

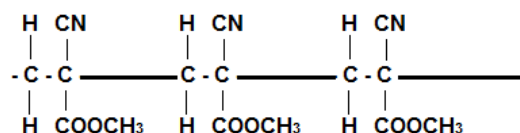35.   Galena is an ore containing lead sulphide, PbS.

   (a) What is the charge on this lead ion?   1

   (b) Calculate the percentage by mass of lead in galena, PbS.   2
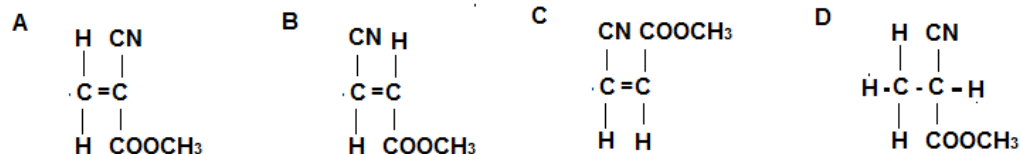
Properties of Plastics

1. The structure below shows a section of an addition polymer.

```
   H  CN        H  CN        H  CN
   |  |         |  |         |  |
 - C - C ------ C - C ------ C - C ------
   |  |         |  |         |  |
   H  COOCH₃    H  COOCH₃    H  COOCH₃
```

Which molecule is used to make this polymer?   1

```
A      H  CN            B     CN  H           C    CN  COOCH₃        D      H  CN
       |  |                   |  |                 |  |                     |  |
      ·C = C                 ·C = C              ·C = C                  H·C - C - H
       |  |                   |  |                 |  |                     |  |
       H  COOCH₃              H  COOCH₃            H  H                     H  COOCH₃
```
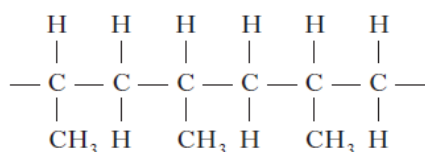
2. Poly(ethenol) is
   A a natural polymer, which is insoluble in water
   B a natural polymer, which is soluble in water
   C a synthetic polymer, which is soluble in water
   D a synthetic polymer, which is insoluble in water.   1
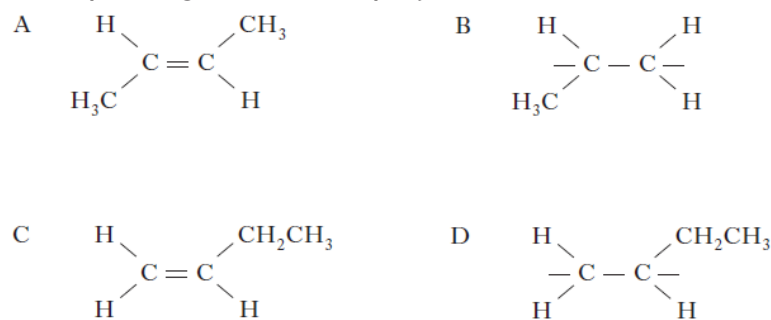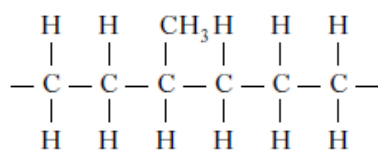
3. Part of the structure of a polymer is drawn below.

```
      H    H    H    H    H    H
      |    |    |    |    |    |
   —  C —  C —  C —  C —  C —  C —
      |    |    |    |    |    |
      CH₃  H    CH₃  H    CH₃  H
```

The repeating unit of this polymer is   1

```
A      H           CH₃          B      H           H
        \         /                     \         /
         C = C                       —  C  —  C —
        /         \                     /         \
      H₃C          H                  H₃C          H


C      H           CH₂CH₃        D      H           CH₂CH₃
        \         /                     \         /
         C = C                       —  C  —  C —
        /         \                     /         \
      H            H                   H           H
```

4. Part of the structure of an addition polymer is shown below. It is made using two different monomers.

```
      H    H    CH₃  H    H    H
      |    |    |    |    |    |
   —  C —  C —  C —  C —  C —  C —
      |    |    |    |    |    |
      H    H    H    H    H    H
```

Which pair of alkenes could be used as monomers for this polymer?
   A Ethene and propene
   B Ethene and butene
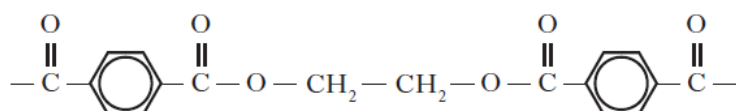   C Propene and butene
   D Ethene and pentene   1

13

5. Which of the following polymers dissolves in water?
   A Kevlar
   B Perspex
   C Poly(ethene)
   D Poly(ethenol)   1

6. Polyethene terephthalate (PET) is used to make plastic bottles which can easily be recycled by heating and reshaping.
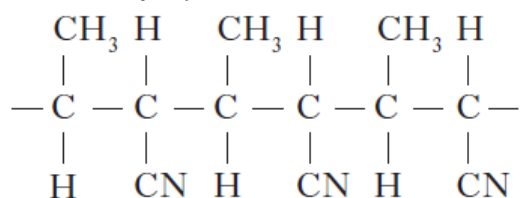   A section of the PET structure is shown.

   Which line in the table best describes PET?   1

	Type of polymer	Property
A	addition	thermoplastic
B	condensation	thermosetting
C	addition	thermosetting
D	condensation	thermoplastic

7. Part of a polymer structure is shown.

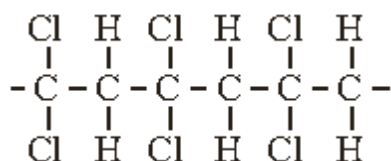   Which of the following gases could **not** be produced when this polymer is burned?
   A CO
   B CO_2
   C HCl
   D HCN   1
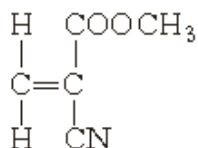
8. Polyvinyldichloride (PVDC) is a plastic used in food packaging.
   The structure of part of a PVDC molecule is shown.

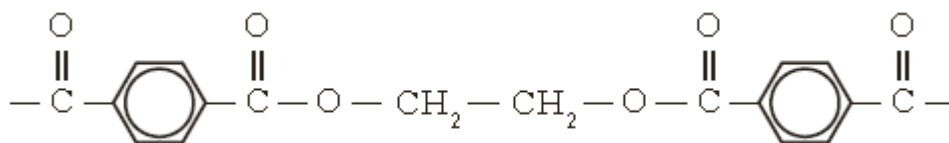   Draw the full structural formula for the monomer used to make PVDC.   1

14

9.   The monomer in superglue has the following structure.

$$\begin{array}{ccc} H & COOCH_3 \\ | & | \\ C & = & C \\ | & | \\ H & CN \end{array}$$

Draw a section of the polymer, showing three monomer units joined together.   1

10.   Polyethene terephthalate (PET) is used to make plastic bottles which can easily be recycled by heating and reshaping.
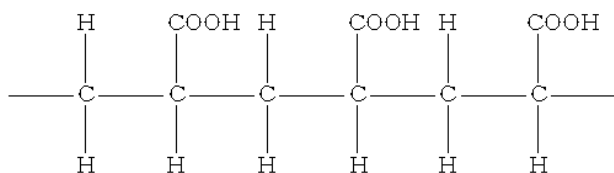A section of the PET structure is shown.

Which line in the table best describes PET?   1

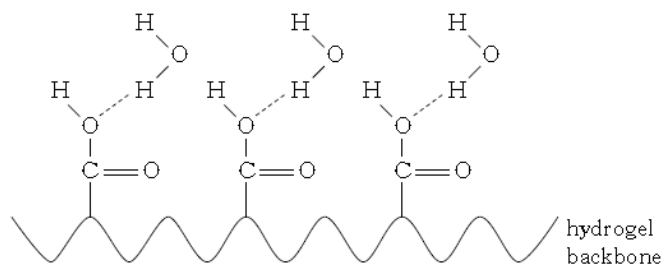|	Type of polymer	Property
A	Addition	Thermoplastic
B	Condensation	Thermosetting
C	Addition	Thermosetting
D	Condensation	Thermoplastic

11.   Synthetic nappies contain hydrogel polymers which attract and absorb water molecules.
The following is part of the structure of a hydrogel polymer.

(a)   Draw the monomer from which this polymer is made.   1

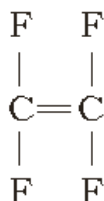(b)   The diagram below shows how water molecules are attracted to the hydrogel.

What type of bonding must be present **in the water molecules**, which allows them to be attracted to the hydrogel?   1

15

12. Some waterproof clothing contains a thin layer of the plastic PTFE.

(a) PTFE is a polymer made from the monomer shown.

$$\begin{array}{ccc} F & & F \\ | & & | \\ C & = & C \\ | & & | \\ F & & F \end{array}$$

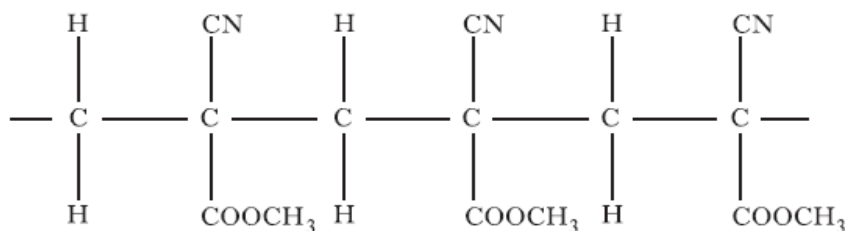Draw a section of the PTFE polymer, showing three monomer units joined together.   1

(b) Name this type of polymerisation reaction.   1

2009 C 18

13. When superglue sets, a polymer is formed.
Part of the polymer structure is shown.

(a) Draw the structure of the repeating unit in the superglue polymer.   1

(b) The polymer shown above contains methyl groups (CH_3).
Another type of superglue, used to close cuts, has the methyl groups replaced by either butyl groups (C_4H_9) or octyl groups.
Complete the table to show the number of carbon and hydrogen atoms in an octyl group.   1

Group	Number of atoms	
	Carbon	Hydrogen
methyl	1	3
butyl	4	9
octyl		

(c) Name a toxic gas given off when superglue burns.   1
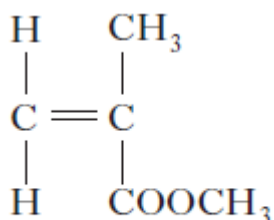
14.   Poly(methyl methacrylate) is a synthetic polymer used to manufacture perspex.

   (a) What is meant by the term synthetic?   1

   (b) The structure of the methyl methacrylate monomer is shown.

$$\begin{array}{ccc} H & & CH_3 \\ | & & | \\ C & = & C \\ | & & | \\ H & & COOCH_3 \end{array}$$

   methyl methacrylate

   (i) Draw a section of the poly(methyl methacrylate) polymer, showing three
       monomer units joined together.   1

   (ii) Name the type of polymerisation taking place.   1
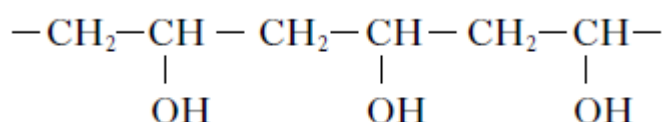
   (c) Name a toxic gas produced when poly(methyl methacrylate) burns.   1

15.   Poly(ethenol) is one of the substances used to cover dishwasher tablets.

   A section of the poly(ethenol) polymer is shown.

$$-CH_2-CH-CH_2-CH-CH_2-CH-$$
$$\quad\quad\;\;|\quad\quad\quad|\quad\quad\quad|$$
$$\quad\quad\;OH\quad\quad OH\quad\quad OH$$

   (a) Name the functional group present in this polymer.   1

   (b) Draw the structure of the repeating unit for this polymer.   1

   (c) A dishwasher tablet, complete with its poly(ethenol) cover, can be added to a
       dishwasher. What property of the poly(ethenol) makes it suitable as a cover
       for a dishwasher tablet?   1
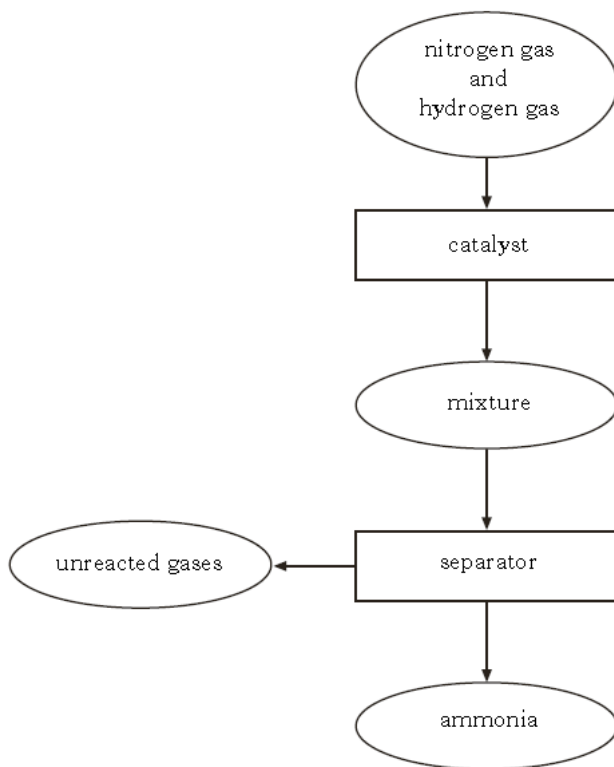
17

Fertilisers

1. Which of the following compounds would not be used as a fertiliser?
    A NH_4NO_3
    B KNO_3
    C $NaCl$
    D K_3PO_4 1

2. Catalysts can be used in different processes.
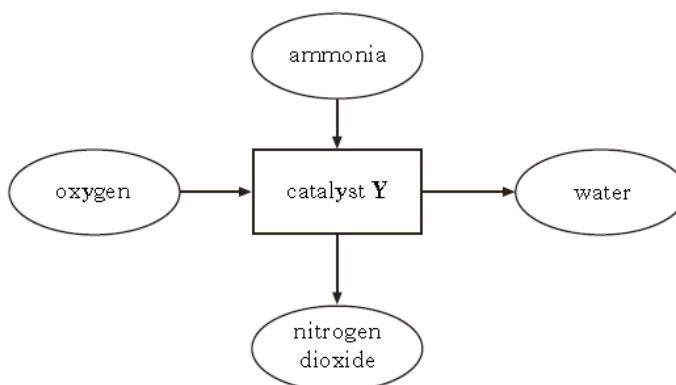   (a)   The flow diagram shows the steps involved in the Haber process.

    Describe how the process could be made more economical.   1

    (b)   Ammonia can be used to produce nitrogen dioxide as shown.

        (i)   Name catalyst Y.   1

        (ii)   Why is it not necessary to continue to supply heat once the reaction
               has started?   1

18

3.   Ammonia is produced in the Haber process.
     Temperature is another factor which affects the percentage yield of ammonia.

Temperature/ °C	Percentage yield of ammonia
200	88
300	67
400	49
500	18

     Suggest a reason why 500 °C is the temperature chosen to operate an industrial
     Ammonia plant rather than 200 °C.   1

4.   Potassium hydroxide reacts with sulphuric acid to form potassium sulphate, which
     can be used as a fertiliser.
     Calculate the percentage, by mass, of potassium in potassium sulphate, K_2SO_4.
     Show your working clearly.   1

5.   Ammonia is made when nitrogen and hydrogen react together.
     The table below shows the percentage yields obtained when nitrogen and hydrogen react
     at different pressures.

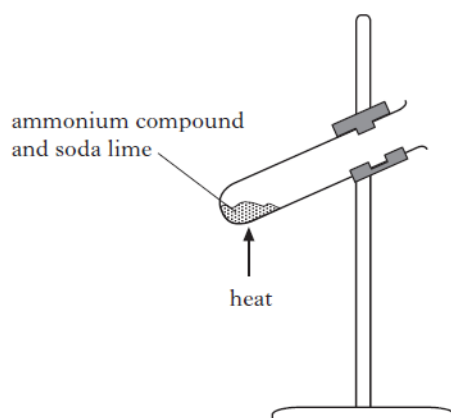| Pressure/atmospheres	Percentage yield of ammonia
25	28
50	40
100	53
200	67
400	80

     (a) Draw a line graph of percentage yield against pressure.   2

     (b) Use your graph to estimate the percentage yield of ammonia at 150 atmospheres.   1
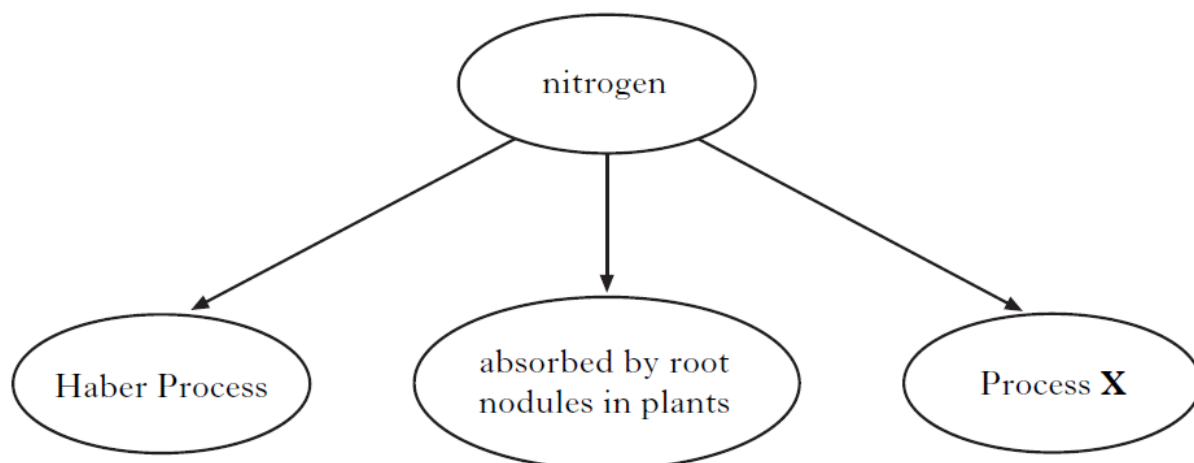
     (c) Ammonia can be produced in the lab by heating an ammonium compound with
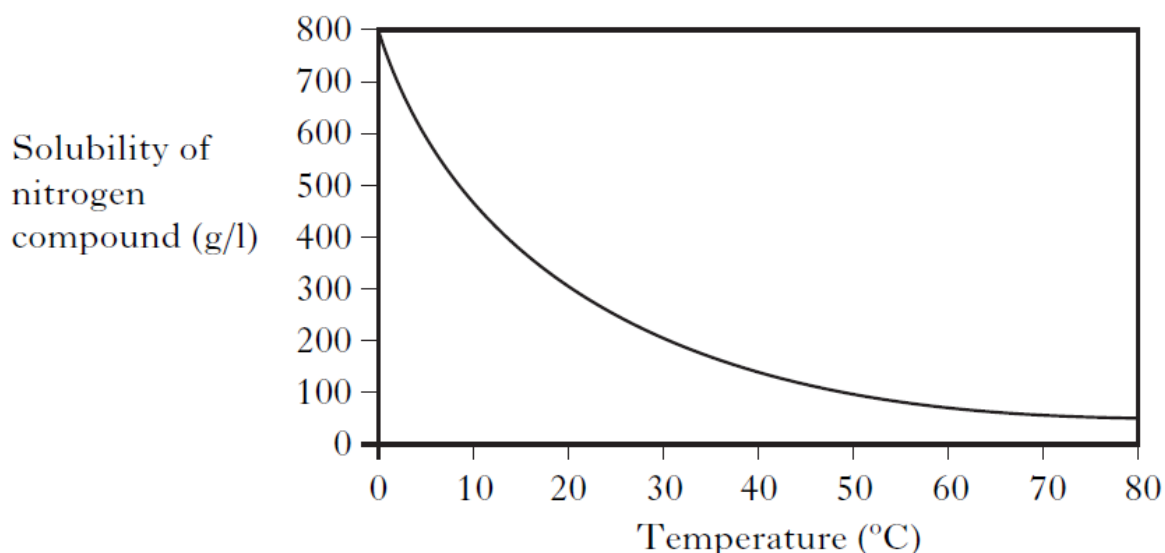   soda lime.

     In order to produce ammonia, what **type** of compound must soda lime be?   1

6.   Nitrogen is essential for healthy plant growth.
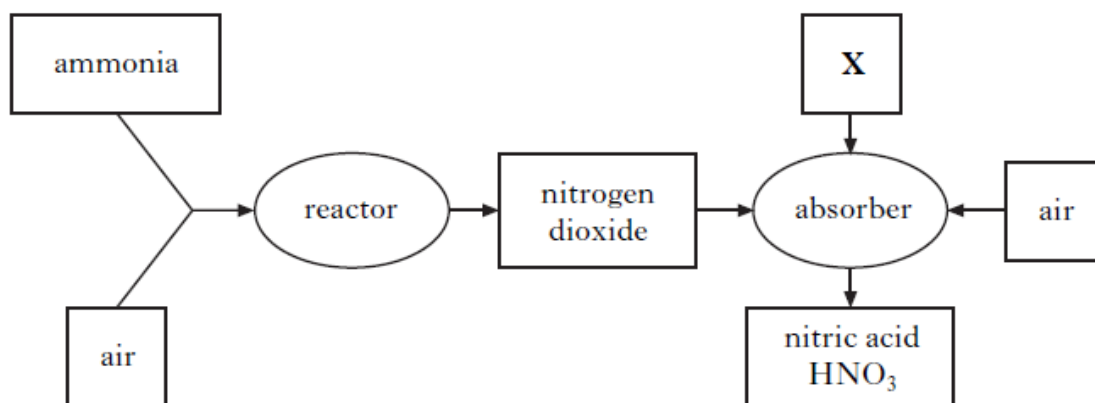   Nitrogen from the atmosphere can be fixed in a number of ways.

(a) X is a natural process which takes place in the atmosphere, producing nitrogen
    dioxide gas.
    What provides the energy for this process?   1

(b) What is present in the root nodules of some plants which convert nitrogen from
    the atmosphere into nitrogen compounds?   1

(c) The Haber Process is the industrial method of converting nitrogen into a
    nitrogen compound.
    Name the nitrogen compound produced.   1

(d) The nitrogen compound produced in the Haber Process dissolves in water.
    The graph shows the solubility of the nitrogen compound at different temperatures.

Write a general statement describing the effect of temperature on the solubility of
the nitrogen compound.   1
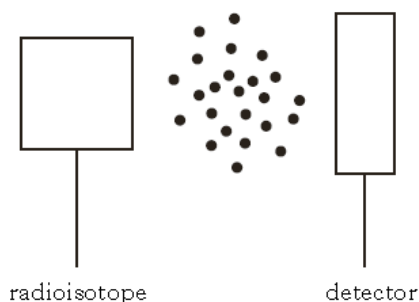
7.   (a) The flow diagram shows how ammonia is converted to nitric acid.

(i) Name the industrial process used to manufacture nitric acid.   1

(ii) The reactor contains a platinum catalyst.
      Why is it not necessary to continue heating the catalyst once the reaction
      has started?   1

(iii) Name substance X.   1

(b) Ammonia and nitric acid react together to form ammonium nitrate, NH_4NO_3.
      Calculate the percentage by mass of nitrogen in ammonium nitrate.
      Show your working clearly.   2

Nuclear Chemistry

1. Some smoke detectors make use of radiation which is very easily stopped by tiny smoke particles moving between the radioactive source and the detector.

radioisotope   detector

The most suitable type of radioisotope for a smoke detector would be
A an alpha-emitter with a long half-life
B a gamma-emitter with a short half-life
C an alpha-emitter with a short half-life
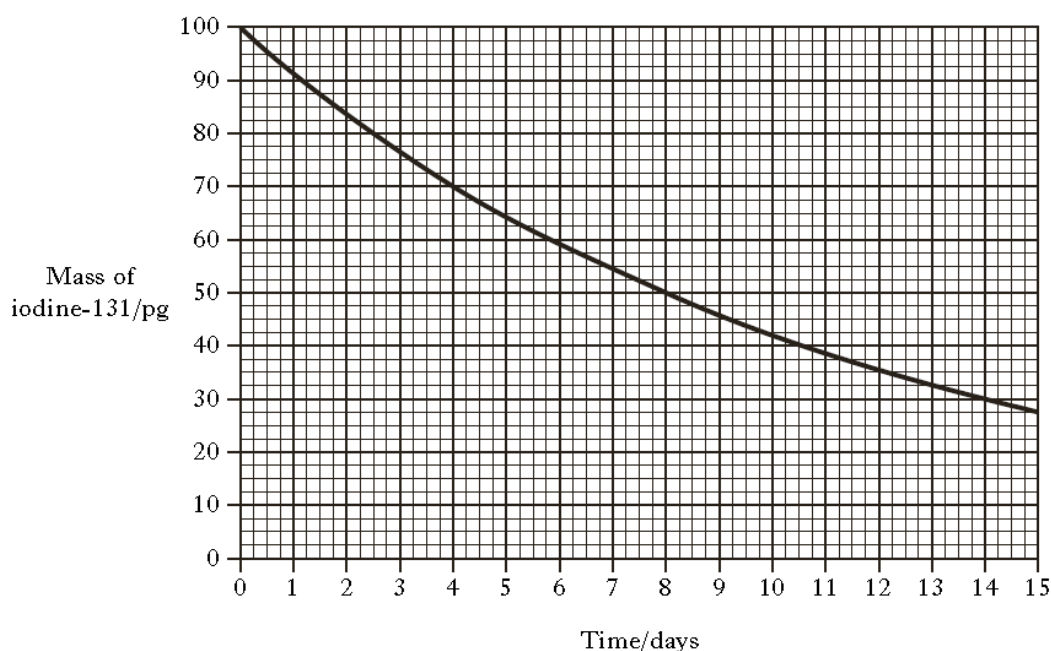D a gamma-emitter with a long half-life.   1

2. The element iodine has only one isotope that is stable. Several of the radioactive Isotopes of iodine have medical uses. Iodine-131, for example, is used in the study of the thyroid gland and it decays by beta emission.

    (a) Complete the balanced nuclear equation for the beta decay of iodine-131.   1

    $$^{131}_{53}\text{I} \qquad \rightarrow$$

    (b) The graph shows how the mass of iodine-131 in a sample changes over a period of time.
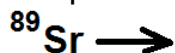

What is the half-life of this isotope?   1

22

3. Phosphorus-32 and strontium-89 are two radioisotopes used to study how far mosquitoes travel.

(a) Strontium-89 decays by emission of a beta particle.
Complete the nuclear equation for the decay of strontium-89. 1

$$^{89}Sr \longrightarrow$$

(b) In an experiment, 10 g of strontium-89 chloride was added to a sugar solution used to feed mosquitoes.
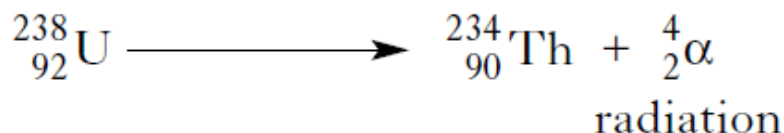The strontium-89 chloride solution was fed to the mosquitoes in a laboratory at 20 °C.
When the mosquitoes were released, the outdoor temperature was found to be 35 °C.
What effect would the increase in temperature have on the half-life of the strontium-89? 1

(c) A mosquito fed on a solution containing phosphorus-32 is released.
Phosphorus-32 has a half-life of 14 days.
When the mosquito is recaptured 28 days later, what fraction of the phosphorus-32 will remain? 1
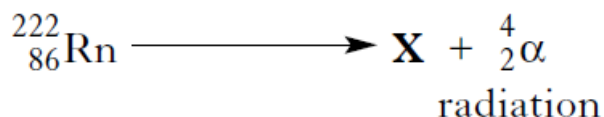
2008 C 15b

4. The element uranium has unstable atoms.
These atoms give out radiation and a new element is formed.

$$^{238}_{92}U \longrightarrow {}^{234}_{90}Th + {}^{4}_{2}\alpha$$
radiation

(a) Complete the table to show the number of each type of particle in $^{234}_{90}Th$. 1

Particle	Number
proton	
neutron	

(b) Radon is another element which gives out radiation.

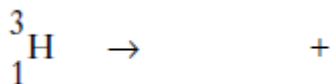$$^{222}_{86}Rn \longrightarrow X + {}^{4}_{2}\alpha$$
radiation

State the atomic number of element X. 1

23

5. Tritium, $^{3}_{1}H$, is an isotope of hydrogen. It is formed in the upper atmosphere when neutrons from cosmic rays are captured by nitrogen atoms.
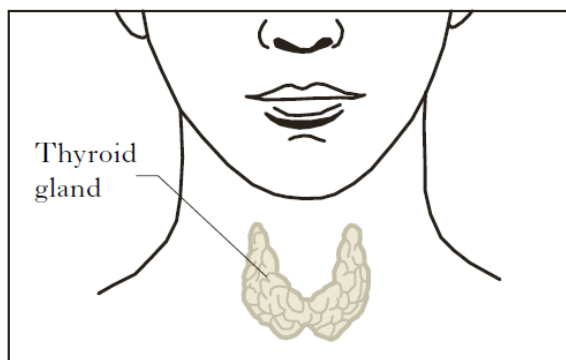
$$^{14}_{7}N + ^{1}_{0}n \rightarrow ^{12}_{6}C + ^{3}_{1}H$$

Tritium atoms then decay by beta-emission.

$$^{3}_{1}H \rightarrow \qquad +$$

(a) Complete the nuclear equation above for the beta-decay of tritium atoms.   1

(b) In the upper atmosphere, tritium atoms are present in some water molecules. Over the years, the concentration of tritium atoms in rain has remained fairly constant.

(i) Why does the concentration of tritium in rain remain fairly constant?   1

(ii) The concentration of tritium atoms in fallen rainwater is found to decrease over time. The age of any product made with water can be estimated by measuring the concentration of tritium atoms.
In a bottle of wine, the concentration of tritium atoms was found to be of the concentration found in rain.
Given that the half-life of tritium is 12.3 years, how old is the wine?   1
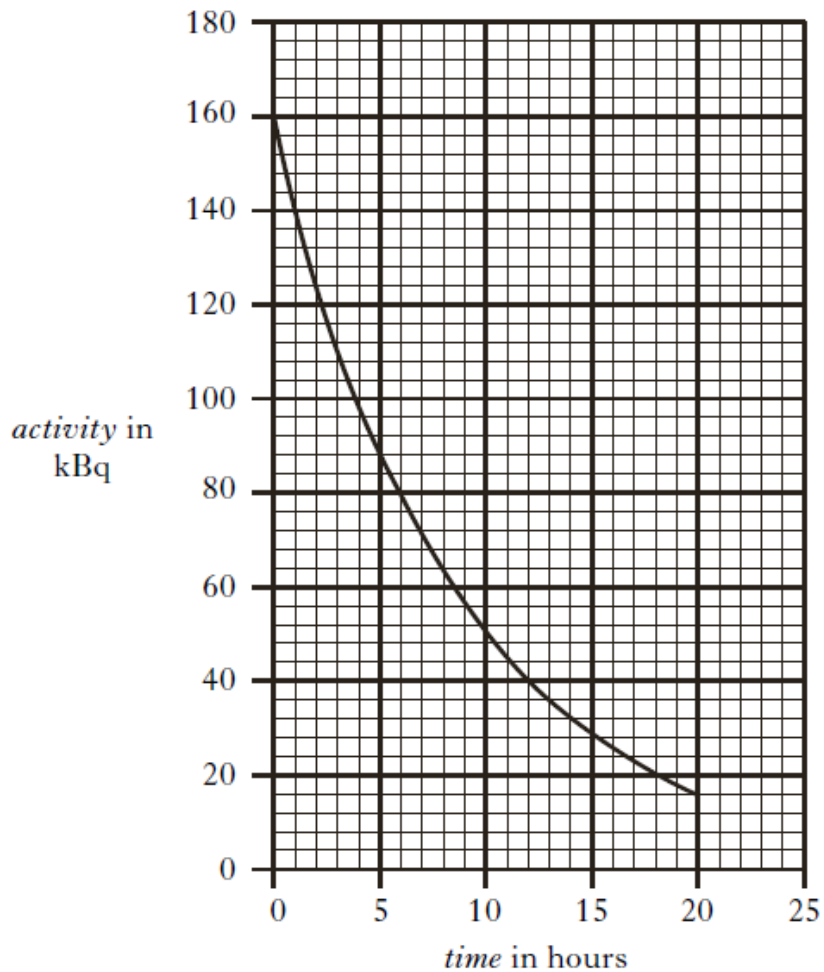
6. The thyroid gland, located in the neck, is essential for maintaining good health.

(a) A radioactive source, which is a gamma radiation emitter, is used as a radioactive tracer for the diagnosis of thyroid gland disorders.
A small quantity of this tracer, with an activity of 20 MBq, is injected into a patient's body. After 52 hours, the activity of the tracer is measured at 1.25MBq.
Calculate the half life of the tracer.   2

(b) Another radioactive source is used to **treat** cancer of the thyroid gland. This source emits only beta radiation.
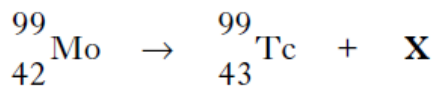Why is this source unsuitable as a **tracer**?   1

7.   A hospital technician is working with a radioactive source. The graph shows the activity of the source over a period of time.

(a) State what is meant by the term half-life.   1

(b) Use information from the graph to calculate the half-life of the radioactive source.   1

(c) The initial activity of the source is 160 kBq.
    Calculate the activity, in kBq, of the radioactive source after four half-lives.   1

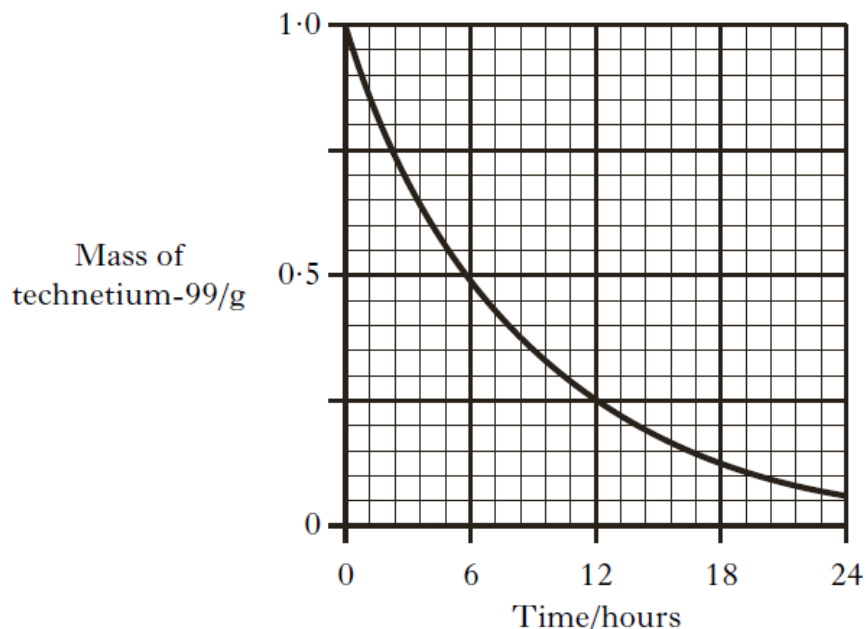8. All the isotopes of technetium are radioactive.
    (a) Technetium-99 is produced as shown.

$$^{99}_{42}\text{Mo} \rightarrow {}^{99}_{43}\text{Tc} + \textbf{X}$$

    Identify X.   1

    (b) The graph shows the decay curve for a 1.0 g sample of technetium-99.

    (i) Copy the graph and sketch another curve to show the variation of mass wit
        time for a 0.5 g sample of technetium-99.   1

    (ii) Technetium-99 is widely used in medicine to detect damage to heart tissue.
        It is a gamma-emitting radioisotope and is injected into the body.
        Suggest one reason why technetium-99 can be safely used in this way.   1

9. An atom of ^{227}Th decays by a series of alpha emissions to form an atom of ^{211}Pb.
    How many alpha particles are released in the process?
    A 2
    B 3
    C 4
    D 5   1

10. The half-life of the isotope ^{210}Pb is 21 years.
    What fraction of the original ^{210}Pb atoms will be present after 63 years?
    A 0.5
    B 0.25
    C 0.125
    D 0.0625   1

Chemical Analysis

1.   When nickel (II) chloride solution is added to sodium carbonate solution an insoluble solid is formed.
      A sample of the solid can be separated from the mixture by
      A condensation
      B distillation
      C evaporation
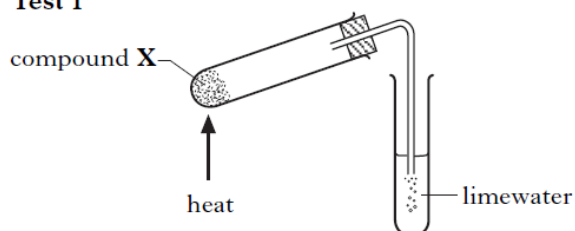   D filtration   1

2.   Which salt can not be prepared by a precipitation reaction?
      (You may wish to use the data booklet to help you.)
      A Barium sulphate
      B Lead(II) sulphate
      C Calcium chloride
      D Silver chloride   1

3.   Two tests were carried out on compound X.

      The following results were obtained.

Test	Result
1	limewater turns cloudy
2	flame turns blue-green

      Which of the following could be compound X?
      (You may wish to use the data booklet to help you.)
      A Barium carbonate
      B Copper carbonate
      C Copper sulphate
      D Sodium sulphate   1

4. Which salt can not be prepared by a precipitation reaction?
    (You may wish to use the data booklet to help you.)
    A Barium sulphate
    B Lead(II) sulphate
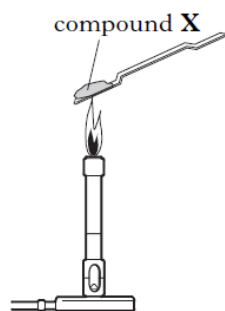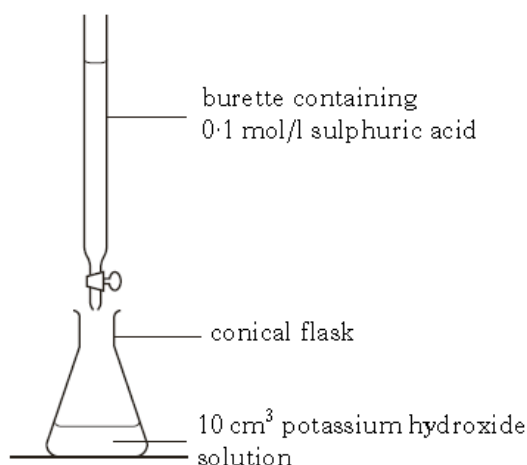   C Calcium chloride
    D Silver chloride   1

5. Potassium sulphate can be produced by titrating potassium hydroxide solution with dilute
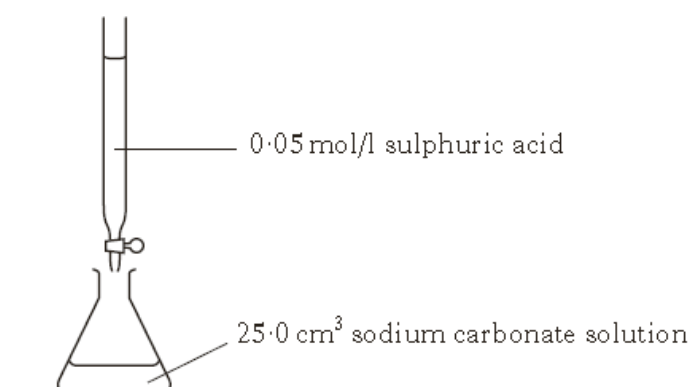   sulphuric acid.

burette containing
0·1 mol/l sulphuric acid

conical flask

10 cm³ potassium hydroxide
solution

(a) What must be added to the conical flask to show the end-point of the titration?   1

(b) The equation for the reaction is:
        H_2SO_4 + 2KOH → K_2SO_4 + $2H_2O$

     The number of moles of sulphuric acid used was 0.002 moles. Using this,
     Calculate the number of moles of potassium hydroxide in the 10cm3 sample
     of potassium hydroxide solution.   2

6. An experiment involved determining the concentration of sodium carbonate solution by
    titration.

0·05 mol/l sulphuric acid

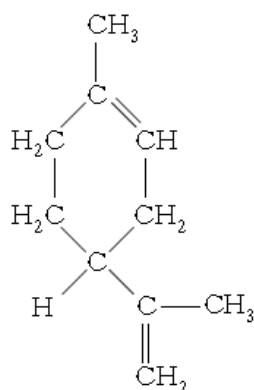25·0 cm³ sodium carbonate solution

    The results showed that 20 cm³ of sulphuric acid was required to neutralise the
    Sodium carbonate solution.
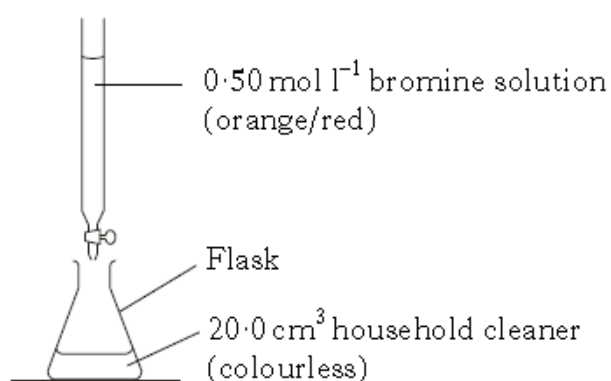   One mole of sulphuric acid reacts with one mole of sodium carbonate.
    0.001 moles of sulphuric acid reacted, calculate the concentration, in mol l^{-1},
    of the sodium carbonate solution.   2

7. Some household cleaners contain the chemical limonene which gives them a lemon smell. The structure of limonene is shown below.
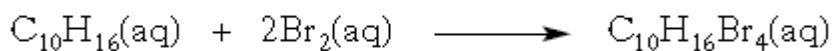

Using bromine solution, a student carried out titrations to determine the concentration of limonene in a household cleaner.

0·50 mol l⁻¹ bromine solution
(orange/red)

Flask

20·0 cm³ household cleaner
(colourless)

Titration	Initial burette reading (cm³)	Final burette reading (cm³)	Titre (cm³)
1	0·5	17·1	16·6
2	0·2	16·3	16·1
3	0·1	16·0	15·9

1

(b) The equation for the reaction between limonene and bromine solution is shown.

$$C_{10}H_{16}(aq) + 2Br_2(aq) \longrightarrow C_{10}H_{16}Br_4(aq)$$

Calculate the concentration of limonene in the household cleaner in mol l⁻¹. 3

8.   Infrared spectroscopy can be used to detect the bonds present in molecules.
The same bond always absorbs infrared radiation at the same wavenumber, even in different molecules.
For example, the C–H bond absorbs in the range 2800 – 3000 wavenumbers.
The infrared spectra of two different organic compounds are shown.

propane

H   H   H
| | |
H – C – C – C – H
| | |
H   H   H

increasing absorption

4000   3600   3200   2800   2400   2000   1600   1200
Wavenumber

butene

H   H   H   H
| | | |
H – C = C – C – C – H
| |
H   H

increasing absorption

4000   3600   3200   2800   2400   2000   1600   1200
Wavenumber

(a) The absorption at wavenumber 1600 in the spectrum of butene is not present in the spectrum of propane.
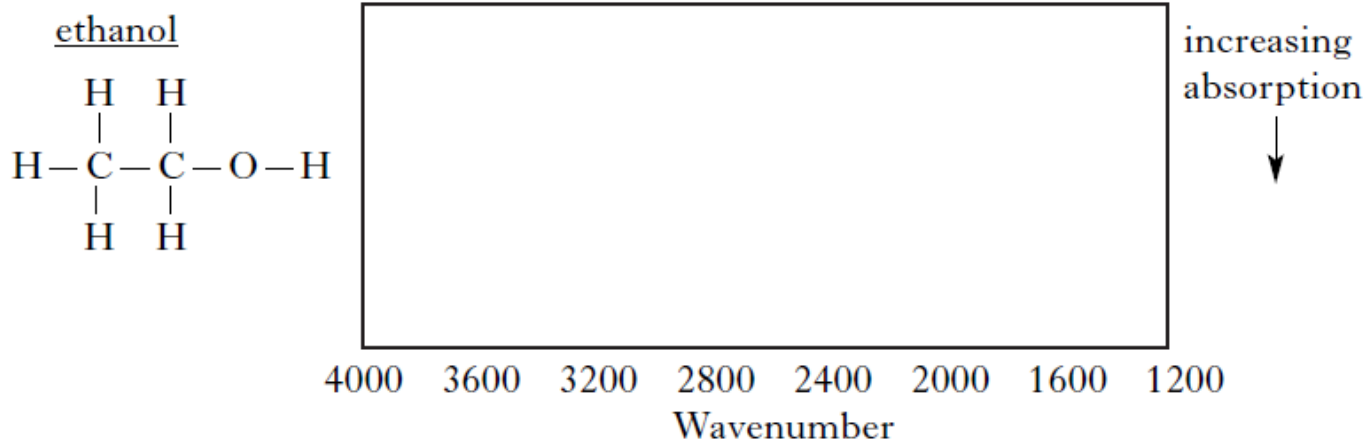Which bond could be responsible for this absorption?   1

(b) The O–H bond absorbs in the range 3500 – 3700 wavenumbers.
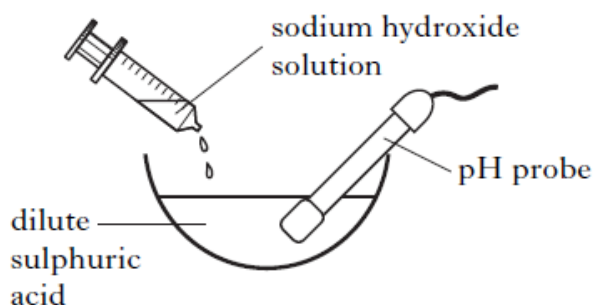Copy the axes below and sketch the infrared spectrum you would predict for ethanol.   1

ethanol

H   H
| |
H – C – C – O – H
| |
H   H

increasing absorption

4000   3600   3200   2800   2400   2000   1600   1200
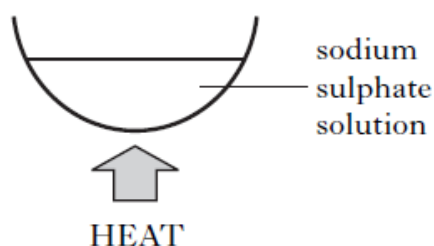Wavenumber

9.   Sodium sulphate crystals can be made from sodium hydroxide solution and dilute sulphuric acid as shown in the procedure below.

Step 1   Add sodium hydroxide solution
                                                to dilute sulphuric acid until

sodium hydroxide
solution

pH probe   _____

dilute
sulphuric
acid

Step 2   Evaporate until half of the
                                                solution remains.

sodium
sulphate
solution

HEAT

Step 3   Leave until the remaining water
                                                evaporates.

sodium
sulphate
solution

Step 4

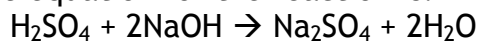sodium   Sodium sulphate crystals are
sulphate   formed.
crystals

(a) Complete the instructions for Step 1.   1
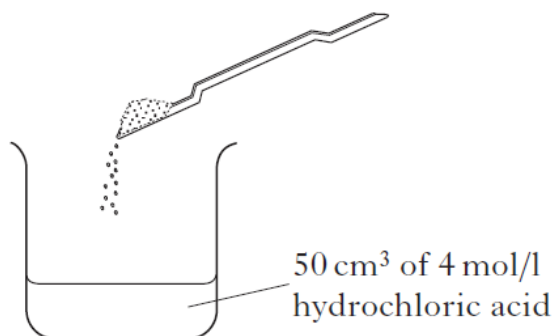
(b) The equation for the reaction is:
        $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$
In the experiment 50cm3 of sodium hydroxide solution reacted with 20cm^3 0·1 mol l^{-1} dilute sulphuric acid.
Calculate the concentration, in mol l^{-1}, of the sodium hydroxide solution.   2
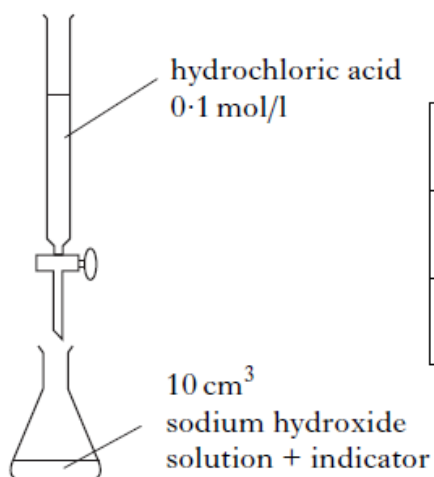
10.   Indigestion is caused by excess acid in the stomach. Indigestion remedies containing calcium carbonate neutralise some of this acid.
Christine carried out an experiment to find the mass of calcium carbonate required to neutralise a dilute hydrochloric acid solution.

$50 \, cm^3$ of $4 \, mol/l$
hydrochloric acid

She added calcium carbonate until all the acid had been used up.

(a) Calculate the number of moles of dilute hydrochloric acid used in the experiment.   1

(b) The equation for the reaction is
$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

(i) Using your answer from part (a), calculate the number of moles of calcium carbonate required to neutralise the dilute hydrochloric acid.   1

(ii) Using your answer from part (b)(i), calculate the **mass** of calcium carbonate ($CaCO_3$) required to neutralise the acid.   1

11. A student carried out a titration using the chemicals and apparatus below.

hydrochloric acid
0·1 mol/l

10 cm^3
sodium hydroxide
solution + indicator

	Rough titre	1st titre	2nd titre
Initial burette reading/cm^3	0·3	0·2	0·5
Final burette reading/cm^3	26·6	25·3	25·4
Volume used/cm^3	26·3	25·1	24·9

(a) Using the results in the table, calculate the average volume of hydrochloric acid required to neutralise the sodium hydroxide solution.　　1
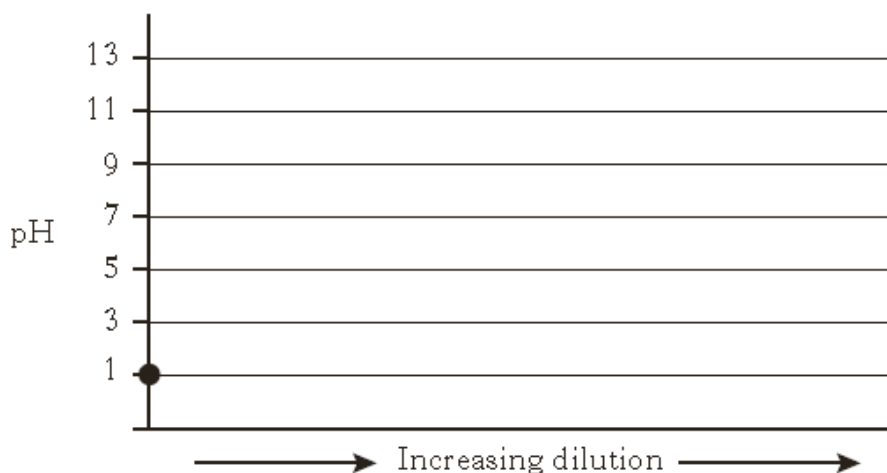
(b) The equation for the reaction is:
      HCl + NaOH → H$_2$O + NaCl
   Using your answer from part (a), calculate the concentration, in mol l^{-1}, of the sodium hydroxide solution.　　2

Problem Solving Questions

1. The table below shows the relationship between the percentage of ethanol and the density of alcoholic drinks.

Percentage of ethanol (%)	40	50	60	70	80
Density of alcoholic drink (g/cm^3)	0·928	0·907	0·886	0·865	0·844

(a) Write a general statement describing how the percentage of ethanol affects the density of the alcoholic drink.   1

(b) The density of a particular brand of alcoholic drink is 0·970 g cm^{-3}.
Predict the percentage of ethanol in this alcoholic drink.   1

2. A solution of 0·1 mol l^{-1} hydrochloric acid has a pH of 1.

(a) What colour would universal indicator turn when added to a solution of hydrochloric acid?   1

(b) Starting at pH 1, draw a line to show how the pH of this acid changes when diluted with water.   1

3. A student investigated how the concentration of sodium chloride in water affected the freezing point.

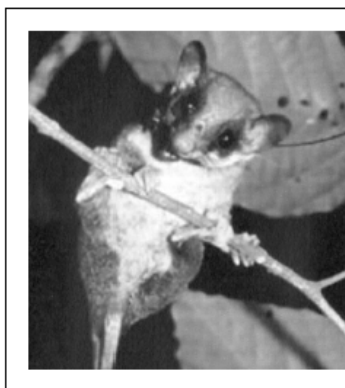   (a) What type of bond is broken in sodium chloride when it dissolves in water?   1

    (b) The table shows information about the freezing point of different sodium chloride solutions.   1

Concentration of sodium chloride solution (mol/l)	0	0·09	0·18	0·27	0·37	0·46
Freezing point (°C)	0	−0·2	−0·5	−0·8	−1·1	−1·5

    Describe the relationship between the concentration and freezing point.   1

    (c) Predict the freezing point of a 0•55 mol/l sodium chloride solution.   1
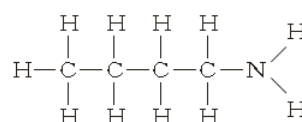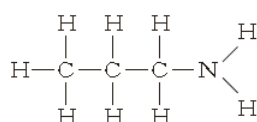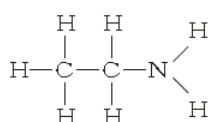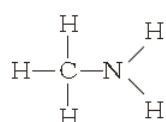
4.

The little pen-tailed tree shrew, found in the jungles of West Malaysia, feeds on nectar from the Bertam palm tree. This nectar contains glucose which ferments, producing solutions of up to 3·8% alcohol. Therefore, the tree shrew regularly drinks a solution which is equivalent to a man drinking 9 units of alcohol per day. It seems that the tree shrew never gets drunk because it is able to breakdown the alcohol much quicker than humans can.

Using information in the passage above, calculate the volume of alcohol solution the tree shrew drinks each day.   1

$$\text{Volume of alcohol solution} = \frac{\text{units of alcohol} \times 1\cdot25}{\text{\% of alcohol}}$$

5. The first four members of the amine homologous series are:

What is the general formula for this homologous series?

A $C_nH_{n+4}N$

B $C_nH_{2n+3}N$

C $C_nH3_{n+2}N$

D $C_nH4_{n+1}N$ 1

6. Some indicators can have different colours when in solutions of different pH values.
The tables give information about two indicators, bromothymol blue and methyl orange.

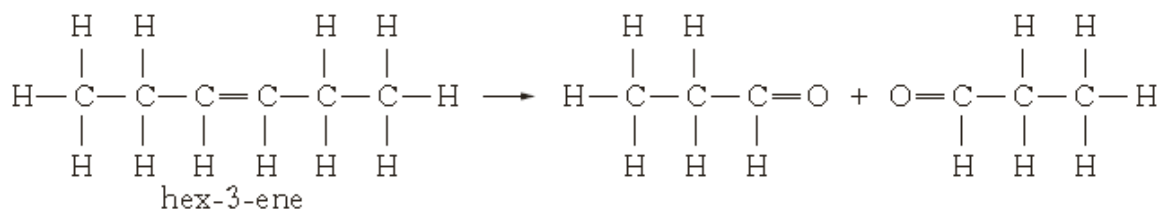| Bromothymol blue	
Colour	pH
yellow	below 6·0
blue	above 7·6

Methyl orange	
Colour	pH
red	below 3·1
yellow	above 4·4

The pH of three solutions was investigated using both indicators.
The results are shown below.

Substance	Colour with bromothymol blue	Colour with methyl orange
A	yellow	red
B	yellow	yellow
C	blue	yellow

(a)   Which solution is alkaline?   1

(b)   Suggest a pH value for solution B.   1

7. Alkenes can undergo different reactions.
In ozonolysis an alkene reacts with ozone forming two molecules. The ozonolysis of hex-3-ene is shown.

```
    H  H         H  H                    H  H                    H  H
    |  |         |  |                    |  |                    |  |
H—C—C—C=C—C—C—H      →      H—C—C—C=O  +  O=C—C—C—H
    |  |  |  |  |  |                    |  |  |                    |  |  |
    H  H  H  H  H  H                    H  H  H                    H  H  H
        hex-3-ene
```

Draw the products formed by the ozonolysis of hex-2-ene.   1

```
    H           H  H  H
    |           |  |  |
H—C—C=C—C—C—C—H   →
    |  |  |  |  |  |
    H  H  H  H  H  H
```