# National 5 Unit 3 Nature's Chemistry

Past Paper Book by Key Area

Metals

1. Metallic bonding is a force of attraction between

    A   negative ions and positive ions
    B   a shared pair of electrons and two nuclei
    C   positive ions and delocalised electrons
    D   negative ions and delocalised electrons

2. Which pair of metals, when connected in a cell, would give the highest voltage and a flow of electrons from **X** to **Y**?
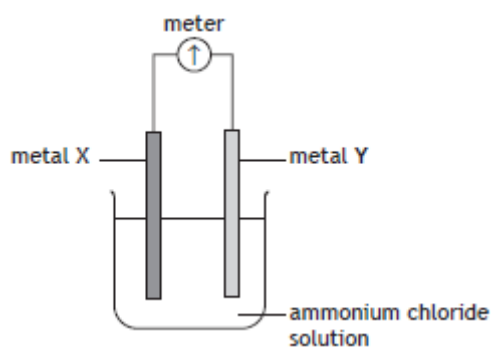

    You may wish to use the data booklet to help you.

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

3. Which of the following metals will **not** react with a dilute solution of hydrochloric acid?

    A   Copper
    B   Iron
    C   Magnesium
    D   Zinc

4. Which metal can be extracted from its oxide by heat alone?

    A   Tin
   B   Zinc
    C   Lead
    D   Silver

5. The ion-electron equations for the oxidation and reduction steps in the reaction between **sulfite ions** and **iron(III) ions** are given below.

    Oxidation $H_2O(\ell) + SO_3^{2-}(aq)$ → $SO_4^{2-}(aq) + 2H^+(aq) + 2e^-$
    Reduction $Fe^{3+}(aq) + e^-$ → $Fe^{2+}(aq)$
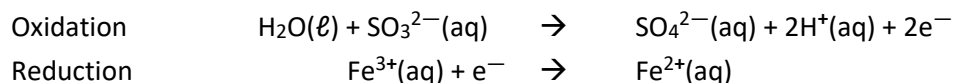
    The redox equation for the overall reaction is

    A $H_2O(\ell) + SO_3^{2-}(aq) + Fe^{3+}(aq)$ → $SO_4^{2-}(aq) + 2H^+(aq) + Fe^{2+}(aq) + e^-$
    B $H_2O(\ell) + SO_3^{2-}(aq) + 2Fe^{3+}(aq)$ → $SO_4^{2-}(aq) + 2H^+(aq) + 2Fe^{2+}(aq)$
    C $SO_4^{2-}(aq) + 2H^+(aq) + Fe^{2+}(aq) + e^-$ → $H_2O(\ell) + SO_3^{2-}(aq) + Fe^{3+}(aq)$
    D $SO_4^{2-}(aq) + 2H^+(aq) + 2Fe^{2+}(aq)$ → $H_2O(\ell) + SO_3^{2-}(aq) + 2Fe^{3+}(aq)$

6. The apparatus below was set up.
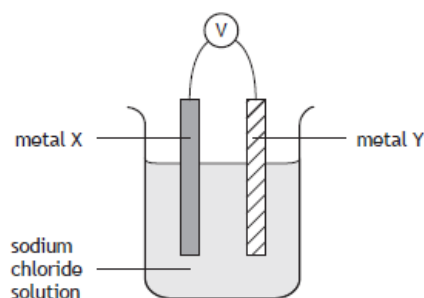
    Which of the following pairs of metals would give the highest reading on the voltmeter?

	Metal X	**Metal Y**
A	Iron	Zinc
B	Magnesium	Silver
C	Zinc	Copper
D	Zinc	Silver

7. 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

8. Which of the following metals would react with zinc chloride solution?
   (You may wish to use the data booklet to help you.)

   A   Copper
   B   Gold
   C   Iron
   D   Magnesium

9.

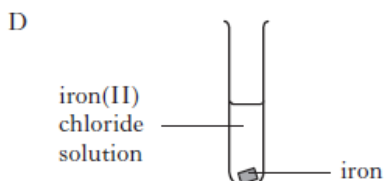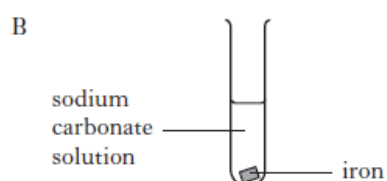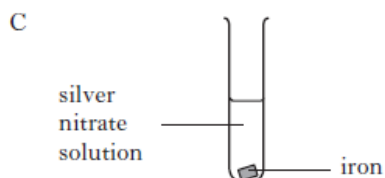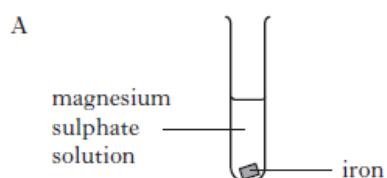| Metal	Reaction with	
	Dilute acid	Water
X	reacts	no reaction
Y	no reaction	no reaction
Z	reacts	reacts

   Which of the following shows the metals in order of **increasing** reactivity?

   A   X Y Z
   B   Y X Z
   C   Z X Y
   D   Z Y X

10. Some metals can be obtained from their metal oxides by heat alone.
    Which of the following oxides would produce a metal when heated?

    A   Calcium oxide
    B   Copper oxide
    C   Zinc oxide
    D   Silver oxide

11. In which of the following test tubes will a reaction occur?

    A
    magnesium
    sulphate
    solution
    iron

    C
    silver
    nitrate
    solution
    iron

    B
    sodium
    carbonate
    solution
    iron

    D
    iron(II)
    chloride
    solution
    iron

12. Four cells were made by joining copper, iron, magnesium and zinc to silver. The four cells produced the following voltages 0·5 V, 0·9 V, 2·7 V and 1·1 V.
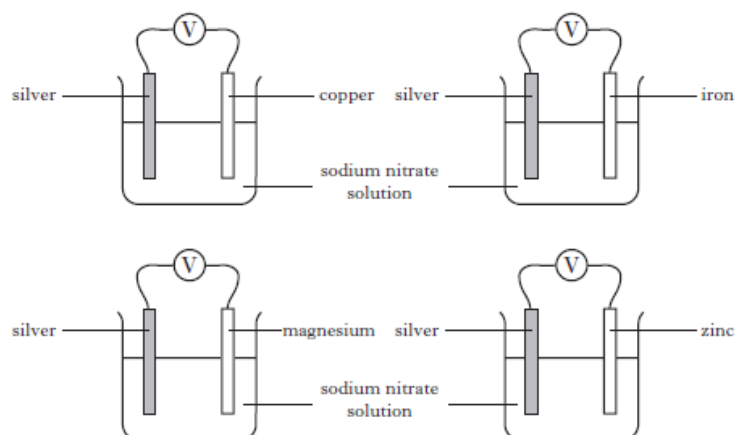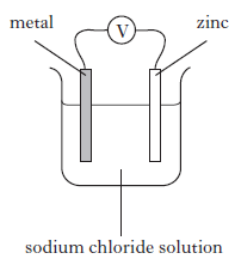

Which of the following will be the voltage of the cell containing silver joined to copper?
(You may wish to use page 7 of the data booklet to help you.)

A   0·5 V
B   0·9 V
C   1·1 V
D   2·7 V

13. A metal can be extracted from its ore by heating the ore with carbon but **not** by heating the ore on its own.
The position of the metal in the reactivity series is most likely to be between
(You may wish to use the data booklet to help you.)

A   zinc and magnesium
B   magnesium and potassium
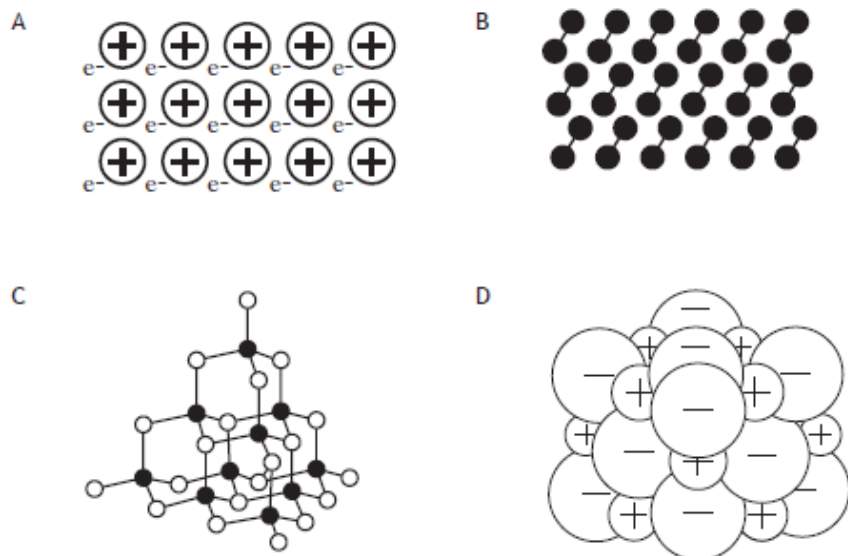C   zinc and copper
D   copper and gold

14.

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

15. Which of the following diagrams could be used to represent the structure of a metal?

A

B

C

D

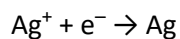16. Which of the following metals does **not** react with dilute acid?

A   Magnesium
B   Calcium
C   Copper
D   Zinc

17. Which of the following metals can be extracted from its oxide by heat alone?

A   Aluminium
B   Iron
C   Silver
D   Zinc
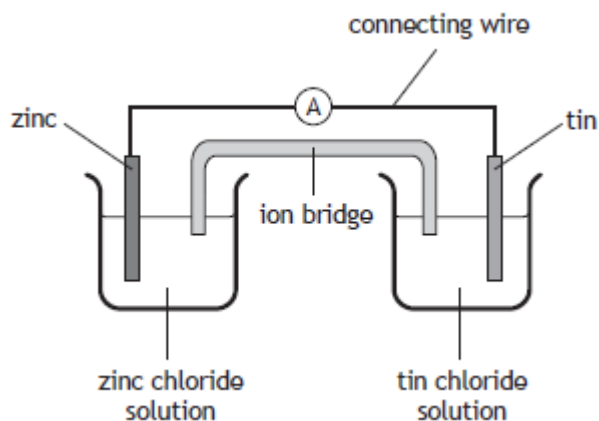
18. The ion-electron equation for the oxidation and reduction steps in the reaction between magnesium and silver(I) ions are:

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

$Ag^+ + e^- \rightarrow Ag$

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

19.

connecting wire

zinc

(A)

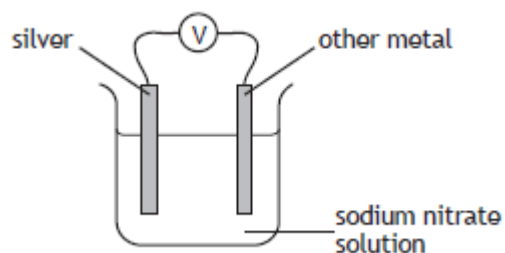tin

ion bridge

zinc chloride
solution

tin chloride
solution

In the cell shown, 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

20. Four cells were made by joining copper, iron, tin and zinc to silver.

silver

(V)

other metal

sodium nitrate
solution

The voltages are shown in the table.
Which line in the table below shows the voltage of the cell containing copper joined to silver?
You may wish to use the data booklet to help you.

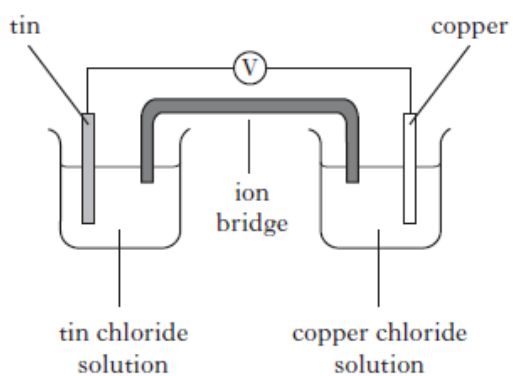| Cell	Voltage (V)
A	1·6
B	1·2
C	0·9
D	0·5

21. Which of the following compounds could be used as an electrolyte in an electrochemical cell?

    A   Hexane
    B   Copper(II) oxide
    C   Calcium chloride
    D   Carbon chloride

22. Which metal can be extracted from its oxide by heat alone?

    A   Lead
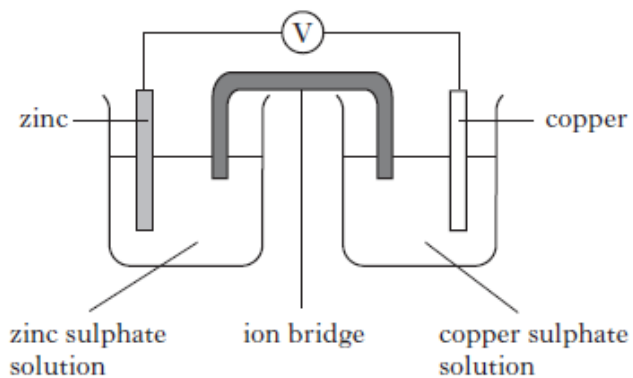   B   Silver
    C   Tin
    D   Zinc

23.

In the cell shown electrons flow through

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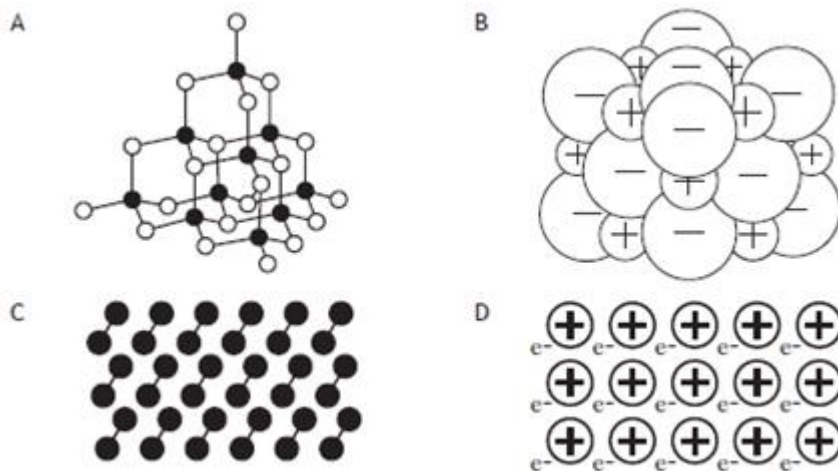   C   the wires from copper to tin
    D   the wires from tin to copper

24.

Which line in the table is correct for the above cell?

	Zinc electrode	Copper electrode
A	mass increases	mass increases
B	mass increases	mass decreases
C	mass decreases	mass decreases
D	mass decreases	mass increases

25. Which of the following diagrams could be used to represent the structure of copper?

26. Which of the following metals is found uncombined in the Earth's crust?
You may wish to use the data booklet to help you.

A   Tin
B   Magnesium
C   Gold
D   Sodium

27. Aluminium can be extracted from naturally occurring metal compounds such as bauxite.

   a) State the term used to describe naturally occurring metal compounds such as bauxite.   **1**

   b) Bauxite is refined to produce aluminium oxide.
      Electrolysis of molten aluminium oxide produces aluminium and oxygen gas.
      The ion-electron equations taking place during the electrolysis of aluminium oxide are

$$Al^{3+} + 3e^- \quad \rightarrow \quad Al$$
$$2O^{2-} \quad \rightarrow \quad O_2 + 4e^-$$
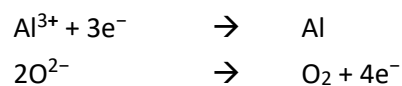
   Write the redox equation for the overall reaction.   **1**

28. A group of students were given strips of aluminium, iron, tin and zinc.
    Using your knowledge of chemistry, suggest how the students could identify each of the four metals.   **3**

29. Titanium is the tenth most commonly occurring element in the Earth's crust.
The first step in the extraction of titanium from impure titanium oxide involves the conversion of titanium oxide into titanium (IV) chloride.

$$TiO_2 + 2Cl_2 + 2C \rightarrow TiCl_4 + 2X$$
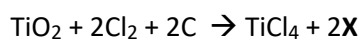
a) Identify **X**.   **1**

b) The next step involves separating pure titanium (IV) chloride from other liquid impurities that are also produced during the first step.
Suggest a name for this process.   **1**

c) The equation for the final step in the extraction of titanium is

$$TiCl_4 + 4Na \rightarrow Ti + 4NaCl$$
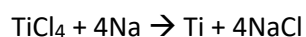
The sodium chloride produced can be electrolysed.
Suggest how this could make the extraction of titanium from titanium oxide more economical.   **1**

30. Chlorine can be produced commercially from concentrated sodium chloride solution in a membrane cell. Only sodium ions can pass through the membrane. These ions move in the direction shown in the diagram.
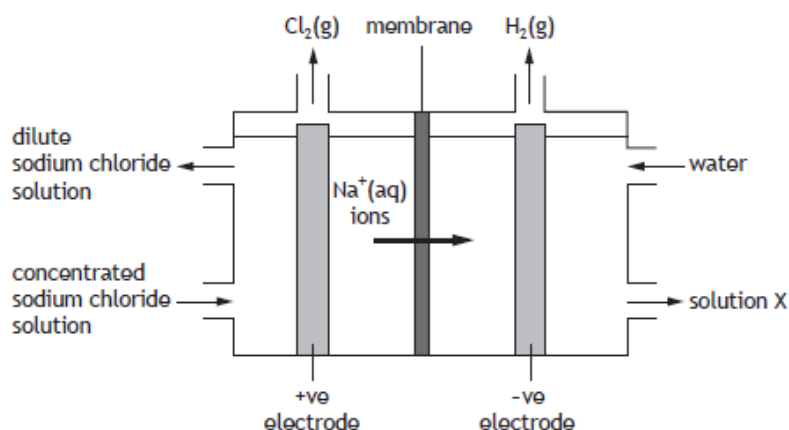
a) Write the ion-electron equation for the change taking place at the positive electrode. **1**
   You may wish to use the data booklet to help you.

b)
   i) Name solution **X**. **1**

   ii) The hydrogen gas produced, at the negative electrode, can be used as a fuel.
   Suggest an advantage of using hydrogen as a fuel. **1**

31. Ores are naturally occurring compounds from which metals can be extracted.
   When a metal is extracted from its ore, metal ions are changed to metal atoms.

a) Name this type of chemical reaction. **1**

b) Iron can be extracted from its ore haematite, Fe_2O_3, in a blast furnace.
   Calculate the percentage by mass of iron in haematite. **3**
   Show your working clearly.

c) Magnesium cannot be extracted from its ore in a blast furnace.
   Suggest a method that would be suitable for the extraction of magnesium from its ore.

   1

32. **Chemistry in the cinema.**

In the film Dante's Peak, a family trapped by red hot lava escape by crossing a large lake in a boat made from aluminium. The volcano releases heat and the gases hydrogen chloride, sulfur dioxide and sulfur trioxide into the water in the lake. While crossing the lake, holes begin to appear in the bottom of the boat. Just after the family leave the boat, on the other side of the lake, the boat sinks.

Using your knowledge of chemistry, comment on whether or not the events described in the film could take place. **3**

33. A student set up the following apparatus to measure the voltage of cells using different combinations of metals.
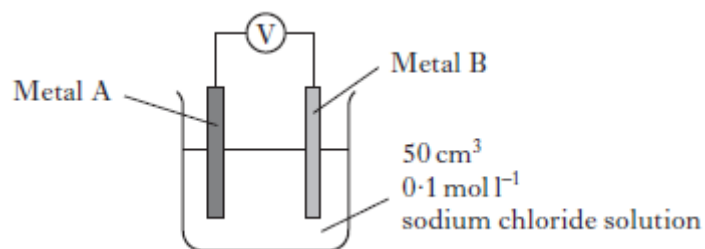
a) State **one** factor which would have to be kept the same to make this investigation fair.   **1**

b) Voltages were produced by the following combinations of metals.

Metal A	Metal B	Voltage (V)
magnesium	lead	2·25
magnesium	iron	1·94
magnesium	zinc	1·62
magnesium	aluminium	0·72

i)   What effect does the reactivity of a metal have on the voltage it produces with magnesium?   **1**

ii)   Predict the voltage, in volts, which would be produced when Metal A is magnesium and Metal B is copper.   **1**

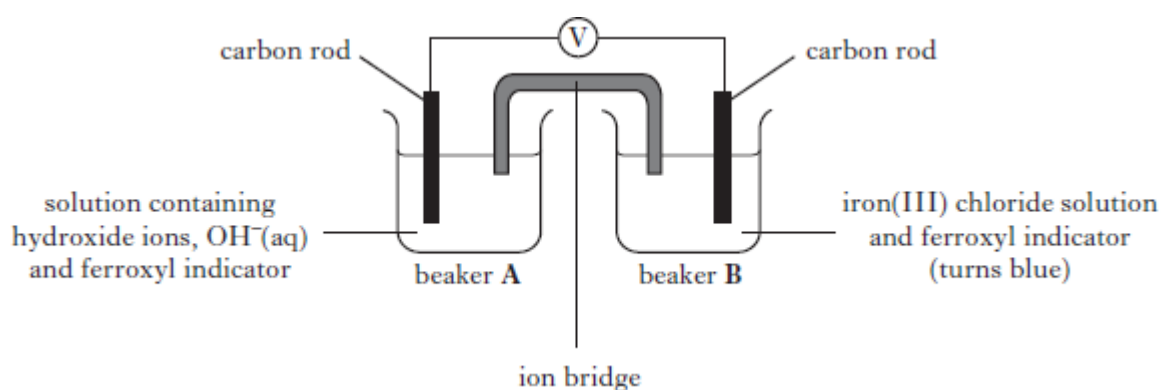iii)   What is the purpose of the sodium chloride solution?   **1**

34. When aluminium is exposed to air it corrodes.

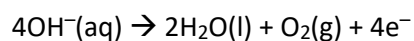Some structures have aluminium and iron parts held together by bolts.
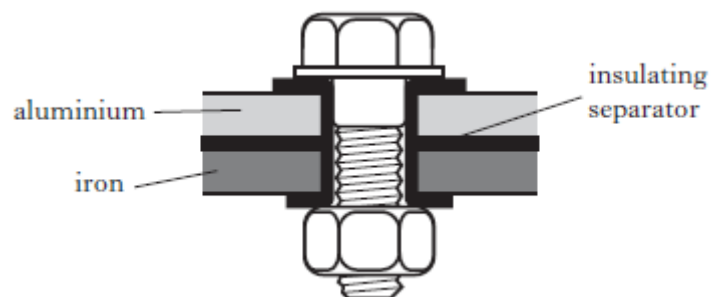
The corrosion of aluminium is an example of oxidation.

Write an ion-electron equation for the oxidation of aluminium. **1**

35. The diagram shows a cell which can produce electricity.

a) In beaker **A** hydroxide ions are converted into water molecules:

$$4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^-$$

On the diagram, clearly mark the path and the direction of the electron flow. **1**

b) What is the purpose of the ion bridge? **1**

36. A gold pendant was hung on a nickel chain. After a short time, the nickel chain corroded.
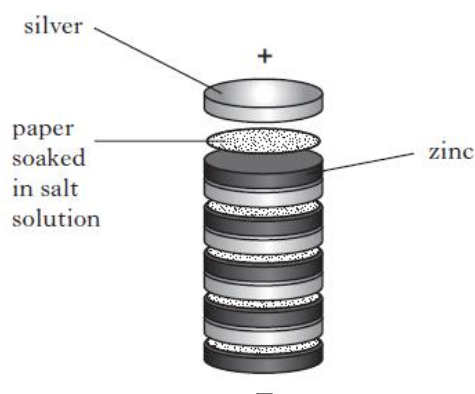

During corrosion, the nickel atoms are oxidised to nickel(II) ions.
Write an ion-electron equation for the oxidation of nickel. **1**
(You may wish to use the data booklet to help you.)

37. Early batteries were made from silver and zinc discs. Paper soaked in salt solution was inserted between the metal discs.

a) What is the purpose of the paper soaked in salt solution? **1**

b) The number of pairs of discs was increased and the voltage measured.

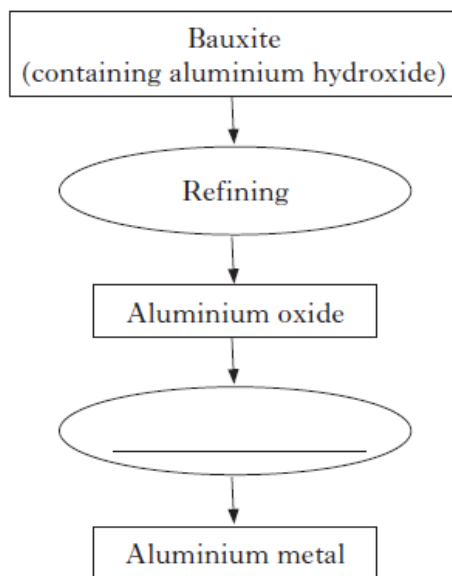| Number of pairs of discs	1	2	3	4	5	6
Voltage (V)	1·56	3·12	4·68	6·24	7·80	9·36

   i) Predict the voltage produced when seven pairs of discs were used. **1**

   ii) What will be the effect on the voltage if the zinc discs are replaced with copper discs? **1**

38. Aluminium has been produced industrially in Scotland since 1926. The process is shown in the flow chart.
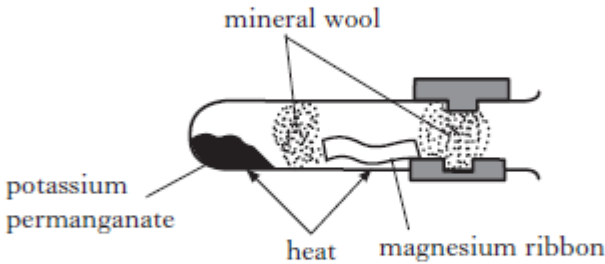

a) What is the name given to naturally occurring compounds of metals such as bauxite?   **1**

b) Complete the flowchart to show the name of the reaction which converts aluminium oxide to aluminium metal.   **1**

39. A student's report is shown for the experiment **"Reaction of metals with oxygen"**.

| Title | Reactions of Metals with Oxygen | Date 15/11/12 |

Aim

**Procedure** The apparatus required to carry out the experiment was collected and assembled as shown.

Results

Metal	Observations
zinc	moderately fast reaction
magnesium	
copper	

a) State the aim of the experiment. **1**

b) Why is potassium permanganate used in this experiment? **1**

c) Complete the table to show the observations for magnesium and copper. **1**

d) For safety reasons this experiment would not be carried out with potassium metal. Suggest a reason for this. **1**

40. 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.

$$4Na + TiCl_4 \rightarrow 4NaCl + Ti$$
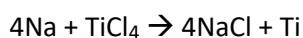
a) What does this method of extraction tell you about the reactivity of titanium metal compared to sodium metal? **1**

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

c) The displacement reaction is carried out in an atmosphere of the noble gas, argon. Suggest why an argon atmosphere is used. **1**

41. Cutlery can be coated with silver to prevent corrosion and to make it look attractive.
Electroplating is a process used to coat the cutlery with silver.
This diagram shows how this can be carried out.
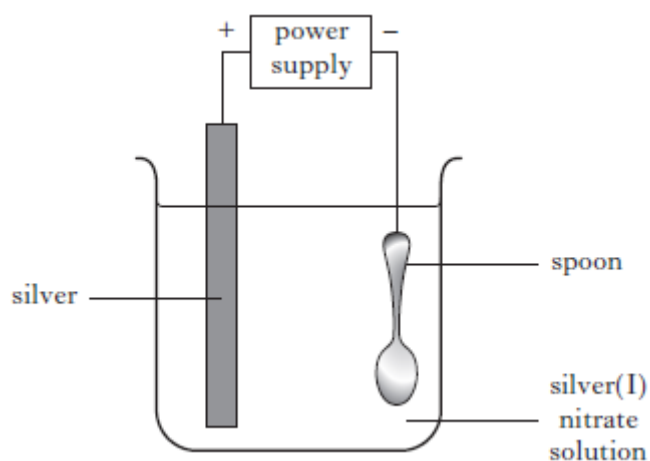
Write the ion-electron equation for the reaction taking place at the positive electrode. **1**
(You may wish to use the data booklet to help you.)

42. 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.
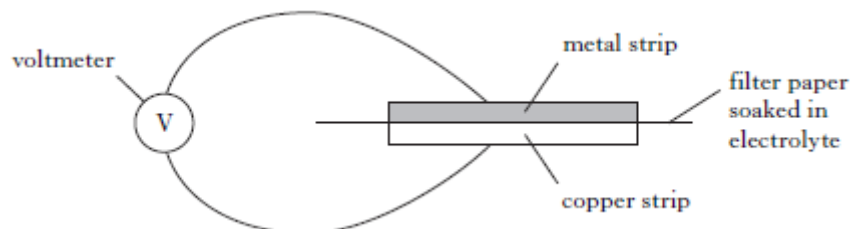
The results are shown.

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

43. Iron is produced from iron ore in a blast furnace.

a) Iron ore, limestone and carbon are added at the top of the blast furnace.
Hot air is blown in near the bottom of the furnace and, through a series of chemical reactions, iron is produced. Waste gases are released near the top of the furnace. A layer of impurities is also produced which floats on top of the iron. The iron and impurities both flow off separately at the bottom of the furnace.

i)   Use this information to complete the diagram.   **2**
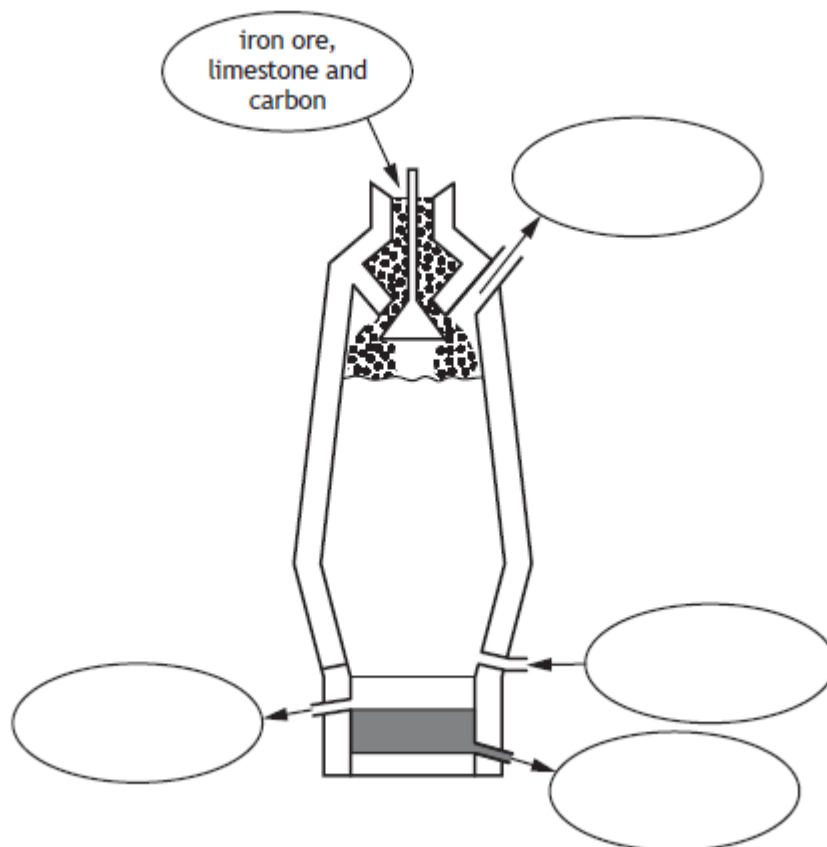
ii)   Explain why the temperature at the bottom of the blast furnace should not drop below 1538 °C.   **1**
You may wish to use the data booklet to help you.

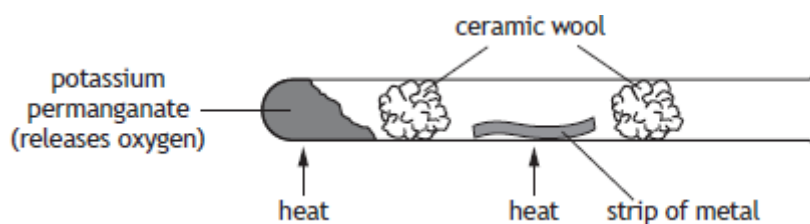b) Rusting occurs when iron is exposed to air and water.
During rusting, iron initially loses two electrons to form iron(II) ions. These ions are further oxidised to form iron(III) ions.
Write an ion-electron equation to show iron(II) ions forming iron(III) ions.   **1**
You may wish to use the data booklet to help you.

44. A teacher demonstrated the following experiment.


The results are shown in the table.

Metal	Observation
zinc	glowed brightly
copper	dull red glow
silver	no reaction

a)

i)   Describe what would be observed if the experiment was repeated using magnesium.

1

ii)   The teacher repeated the experiment using copper powder.
      State the effect this would have on the rate of the reaction between copper and
      oxygen.   1

b) Magnesium also reacts with steam to produce magnesium oxide and hydrogen gas.

$$Mg(s) + H_2O(g) \rightarrow MgO(s) + H_2(g)$$
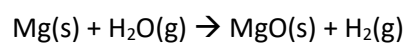
Identify the substance which is being oxidised.   1

45. A student set up an electrochemical cell using aluminium and copper electrodes as well as aluminium sulfate solution and copper(II) sulfate solution.

a)

  i) Complete the labels on the diagram to show the electrochemical cell which would give the direction of electron flow indicated. **1**
  You may wish to use the data booklet to help you.
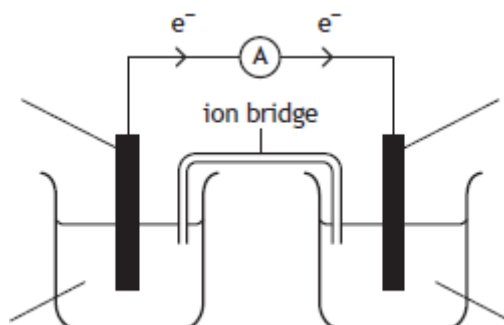
  ii) The two reactions which take place in the cell are

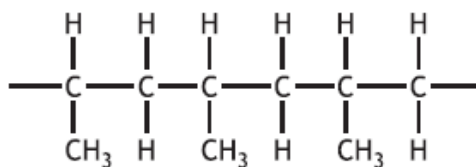$$Al(s) \rightarrow Al^{3+}(aq) + 3e^-$$
$$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$$
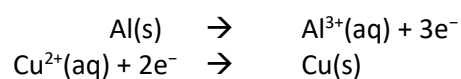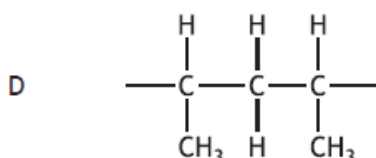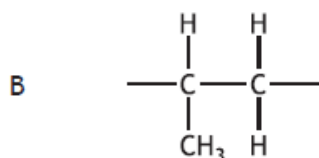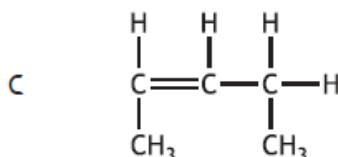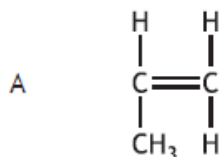
  Write the redox equation for the overall reaction. **1**

b) Calculate the percentage by mass of aluminium in aluminium sulfate, $Al_2(SO_4)_3$.
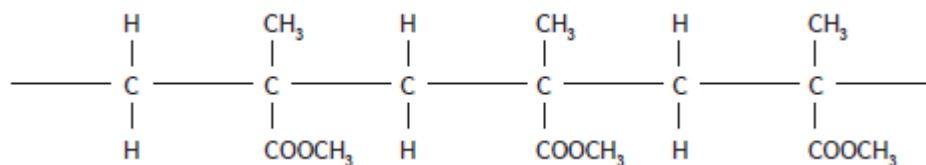   **Show your working clearly.**
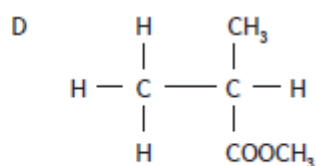
Properties of Plastics

46. Part of the structure of a polymer is drawn below.

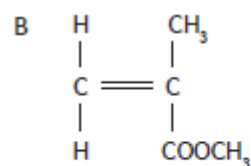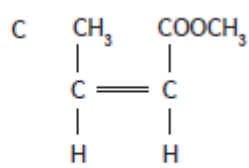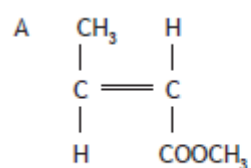The monomer used to make this polymer is

A

C

B

D

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

Which of the following molecules is used to make this polymer?

A

C

B

D

48. Poly(vinylcarbazole) is a plastic which conducts electricity when exposed to light.
The structure of the monomer used to make poly(vinylcarbazole) is

$$\begin{array}{c} NC_{12}H_8 \quad H \\ | \qquad\quad | \\ C = C \\ | \qquad\quad | \\ H \qquad\quad H \end{array}$$
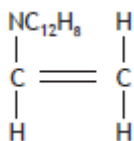
a) Draw a section of the polymer showing three monomer units joined together.　　　**1**

b) Name the type of polymerisation taking place when these monomers join together.　　　**1**

49. Superglue is used widely. Care must be taken when using superglue.

SUPERGLUE
Warning: Keep away
from wool and cotton

Superglue contains the compound methyl-2-cyanopropenoate.
Its structure is shown.

$$\begin{array}{c} H \quad\ CN \\ | \qquad\ | \\ C = C \\ | \qquad\ | \\ H \quad COOCH_3 \end{array}$$
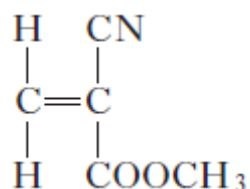
On exposure to air the polymer poly(methyl-2-cyanopropenoate) is formed.
Draw a section of the polymer showing 3 repeating units.　　　**1**

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

PTFE is a polymer made from the monomer shown.

$$
\begin{array}{ccc}
F & & F \\
| & & | \\
C & = & C \\
| & & | \\
F & & F
\end{array}
$$
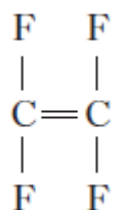
a) Draw a section of the PTFE polymer, showing three monomer units joined together.   **1**

b) Name this type of polymerisation reaction.   **1**

Fertilisers

51. Which of the following is **not** an essential element for healthy plant growth?

    A   Oxygen
    B   Nitrogen
    C   Potassium
    D   Phosphorus

52. The Haber process is the industrial process for the manufacture of

    A   nitric acid
    B   ammonia
    C   alkenes
    D   esters.

53. A researcher investigated the conditions for producing ammonia.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

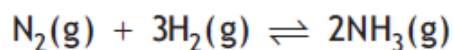a) Name the catalyst used in the production of ammonia.   **1**

b) In her first experiment she measured how the percentage yield of ammonia varied with pressure at a constant temperature of 500 ºC.

Pressure (atmospheres)	100	200	300	400	500
Percentage yield (%)	10	18	26	32	40

Predict the percentage yield of ammonia at 700 atmospheres.   **1**

c) In a second experiment the researcher kept the pressure constant, at 200 atmospheres, and changed the temperature as shown.

Temperature (°C)	200	300	400	500
Percentage yield (%)	89	67	39	18

Describe how the percentage yield varies with temperature.   **1**

d) **Using the information in both tables**, suggest the combination of temperature and pressure that would produce the highest percentage yield of ammonia.   **1**

54. The manufacture of potassium nitrate, for use in fertilisers, can be split into three stages.

a) In stage **1**, ammonia is produced.

Name the industrial process used to manufacture ammonia.   **1**

b) In stage **2**, ammonia is converted into nitric acid, HNO_3, as shown in the flow diagram.
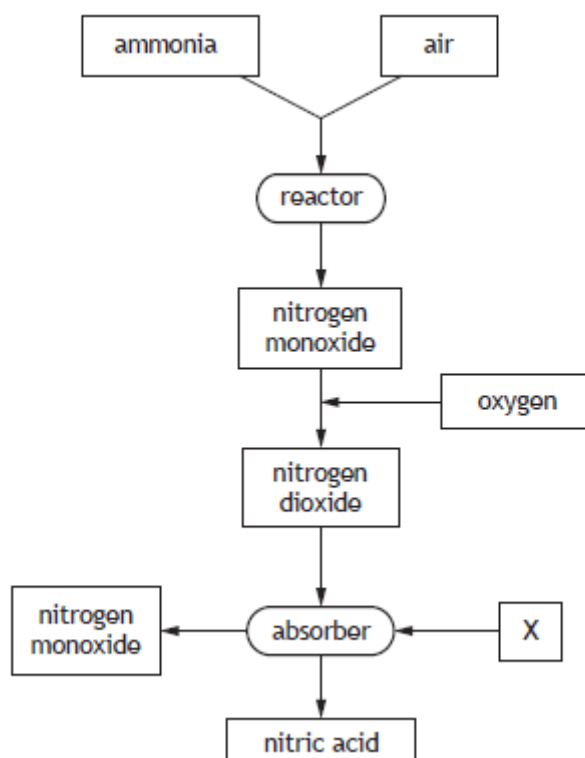
i)   Name substance **X**.   **1**

ii)   **On the flow diagram**, draw an arrow to show how the process can be made more economical.   **1**

55. Urea, H_2NCONH_2, can be used as a fertiliser.

   a) Calculate the percentage of nitrogen in urea.   **3**
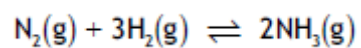   **Show your working clearly.**

   b) Other nitrogen based fertilisers can be produced from ammonia.
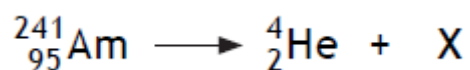   In industry, ammonia is produced in the Haber process using a catalyst.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

     Suggest why a catalyst may be used in an industrial process.   **1**

Nuclear Chemistry

56. Americium-241, a radioisotope used in smoke detectors, has a half-life of 432 years.
The equation for the decay of americium-241 is

$$^{241}_{95}\text{Am} \longrightarrow {}^{4}_{2}\text{He} + \text{X}$$

a) Name element **X**.   **1**

b) Name the type of radiation emitted by the americium-241 radioisotope.   **1**

c) Another radioisotope of americium exists which has an atomic mass of 242.
Americium-242 has a half-life of 16 hours.

   i)   A sample of americium-242 has a mass of 8 g.
           Calculate the mass, in grams, of americium-242 that would be left after 48 hours.
           Show your working clearly.   **3**

   ii)   Suggest why americium-241, and not americium-242, is the radioisotope used in
           smoke detectors.   **1**

57. Different types of radiation have different penetrating properties.
An investigation was carried out using three radioactive sources.
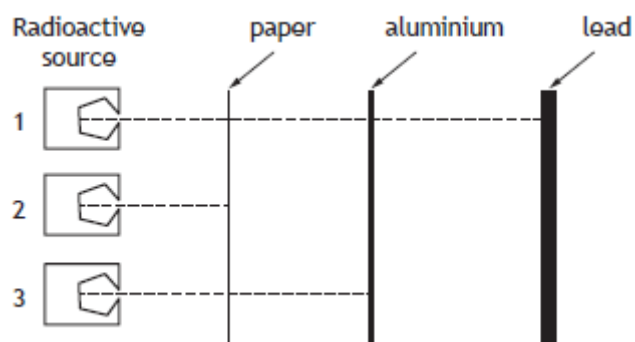
a) Name the type of radiation emitted by source **2**.   **1**

b) The half-life of source **3** is 8 days.
Calculate the fraction of source **3** that would remain after 16 days.   **2**
Show your working clearly.

c) Radioisotopes can be made by scientists.
The nuclear equation shows how a radioisotope of element **X** can be made from aluminium.

$$^{27}_{13}\text{Al} \quad + \quad ^{1}_{0}\text{n} \quad \longrightarrow \quad \text{X} \quad + \quad ^{4}_{2}\text{He}$$

Name element **X**.   **1**

58. Technetium-99m is used in medicine to detect damage to heart tissue.
    It is a gamma-emitting radioisotope and is injected into the body.

    a) The half-life of technetium-99m is 6 hours.
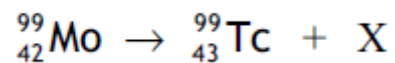   How much of a 2 g sample of technetium-99m would be left after 12 hours?   **2**

    b) Suggest one reason why technetium-99m can be used safely in this way.   **1**

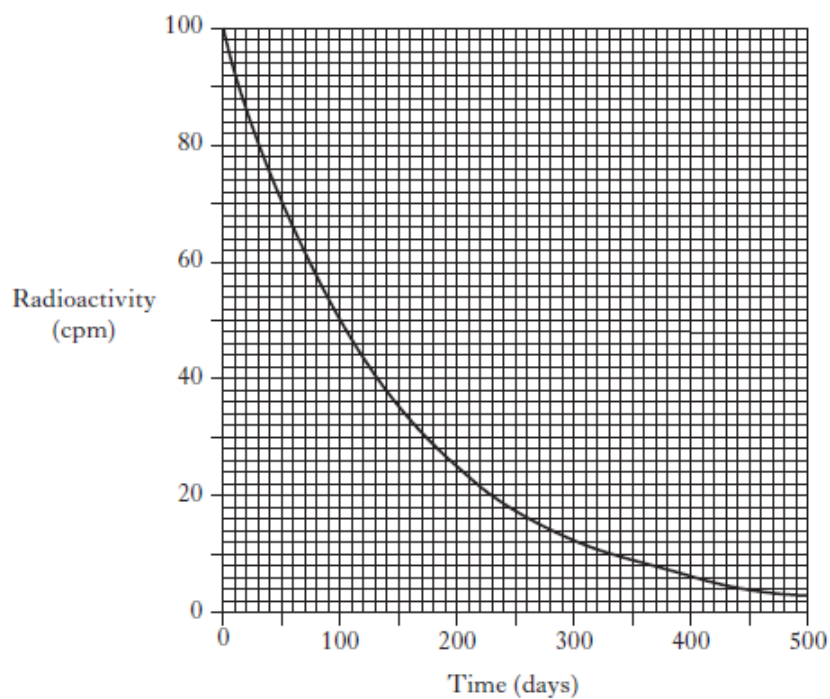   c) Technetium-99 is formed when molybdenum-99 decays.
       The decay equation is:

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

    Identify **X**.   **1**

59. The isotope $^{210}_{84}Po$ is radioactive and the level of radioactivity decreases over time as shown.
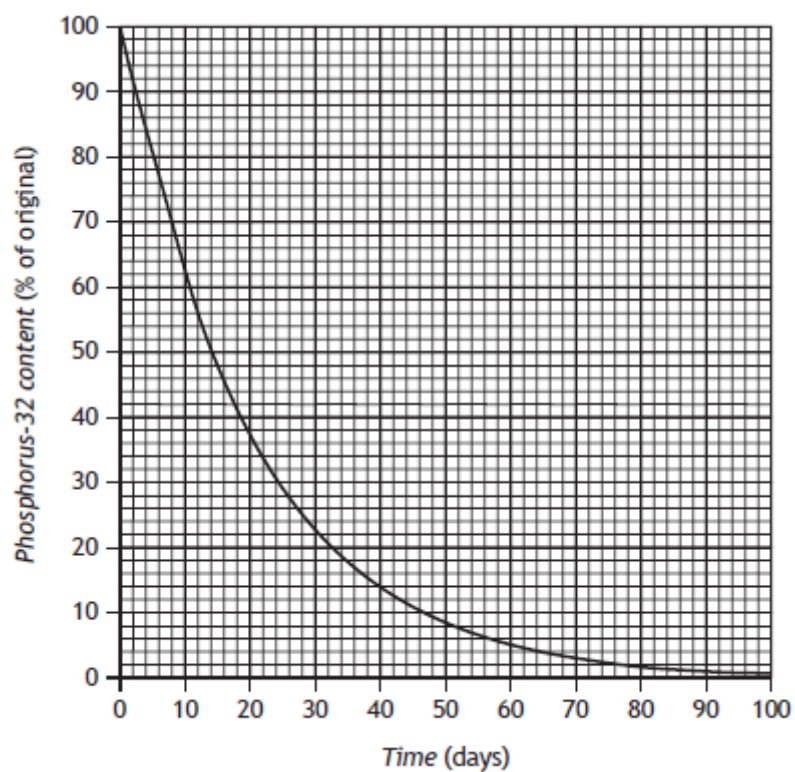

How long would it take for the radioactivity to fall from 100 cpm to 20 cpm?   **1**

60. Phosphorus-32 is a radioisotope used in the detection of cancerous tumours.
    a) The graph shows how the percentage of phosphorus-32 in a sample changes over a period of time.

i)   Using the graph, calculate the half-life, in days, of phosphorus-32.   **1**

ii)   Using your answer to part (a) (i), calculate the time, in days, it would take for the mass of a 20 g sample of the radioisotope to decrease to 2·5 g.   **2**

    b) Phosphorus-32 decays by emitting radiation.
       During this decay the atomic number increases by 1.
       Name the type of radiation emitted when phosphorus-32 decays.   **1**