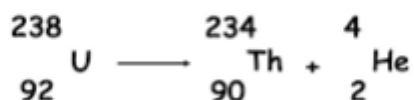


# National 5 Chemistry

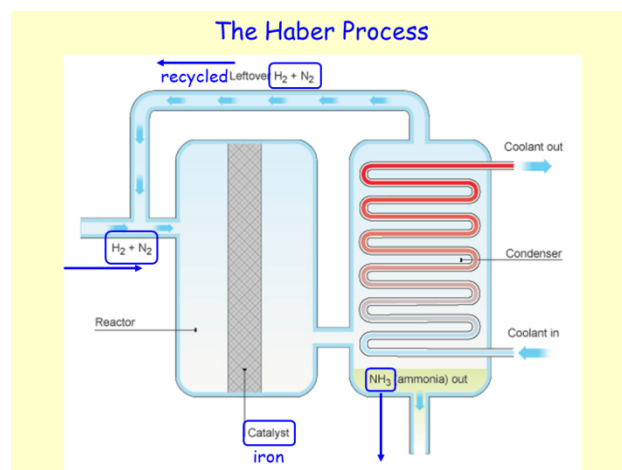
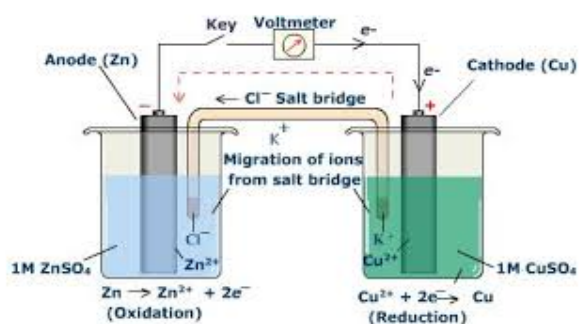
## Unit 3 Past Paper Questions

### Nuclear Equations

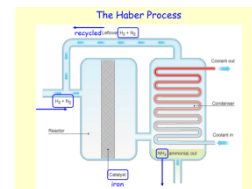
*Mass numbers:  $234 + 4 = 238$*



*Atomic numbers:  $90 + 2 = 92$*

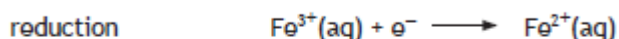
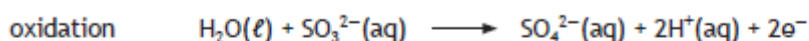


## Unit 3 Chemistry in Society



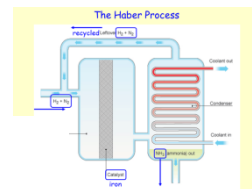
### Section 1

- Which of the following metals will not react with a dilute solution of hydrochloric acid?
  - Copper
  - Iron
  - Magnesium
  - Zinc
- Which metal can be extracted from its oxide by heat alone?
  - Tin
  - Zinc
  - Lead
  - Silver
- The ion-electron equations for the oxidation and reduction steps in the reaction between sulfite ions and iron(III) ions are given below.

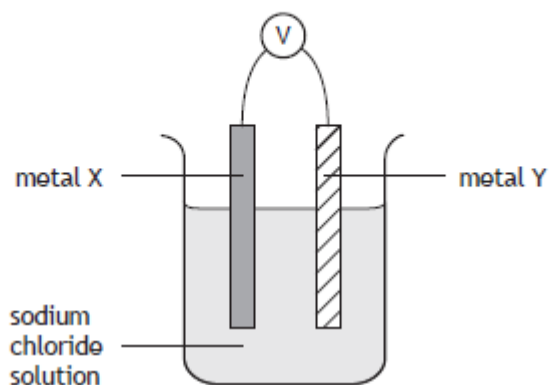


The redox equation for the overall reaction is

- $\text{H}_2\text{O}(\ell) + \text{SO}_3^{2-}(\text{aq}) + \text{Fe}^{3+}(\text{aq}) \longrightarrow \text{SO}_4^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) + \text{Fe}^{2+}(\text{aq}) + \text{e}^-$
- $\text{H}_2\text{O}(\ell) + \text{SO}_3^{2-}(\text{aq}) + 2\text{Fe}^{3+}(\text{aq}) \longrightarrow \text{SO}_4^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{Fe}^{2+}(\text{aq})$
- $\text{SO}_4^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) + \text{Fe}^{2+}(\text{aq}) + \text{e}^- \longrightarrow \text{H}_2\text{O}(\ell) + \text{SO}_3^{2-}(\text{aq}) + \text{Fe}^{3+}(\text{aq})$
- $\text{SO}_4^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{Fe}^{2+}(\text{aq}) \longrightarrow \text{H}_2\text{O}(\ell) + \text{SO}_3^{2-}(\text{aq}) + 2\text{Fe}^{3+}(\text{aq})$



4. The apparatus below was set up.

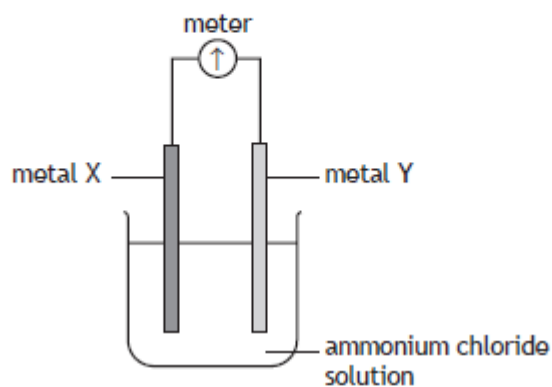


Which of the following pairs of metals would give the highest reading on the voltmeter?

- |   | Metal X   | Metal Y |
|---|-----------|---------|
| A | Iron      | Zinc    |
| B | Magnesium | Silver  |
| C | Zinc      | Copper  |
| D | Zinc      | Silver  |
5.  $\text{Ba}^{2+}(\text{aq}) + 2\text{NO}_3^{-}(\text{aq}) + 2\text{Na}^{+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \longrightarrow \text{Ba}^{2+}\text{SO}_4^{2-}(\text{s}) + 2\text{Na}^{+}(\text{aq}) + 2\text{NO}_3^{-}(\text{aq})$
- The type of reaction represented by the equation above is
- A addition
- B displacement
- C neutralisation
- D precipitation.
6. 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.



7. 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.

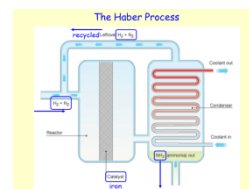
	<i>Metal X</i>	<i>Metal Y</i>
A	zinc	tin
B	tin	zinc
C	copper	magnesium
D	magnesium	copper

8. Sodium sulfate solution reacts with barium chloride solution.

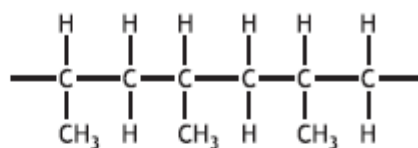


The spectator ions present in this reaction are

- A  $\text{Na}^+$  and  $\text{Cl}^-$
- B  $\text{Na}^+$  and  $\text{SO}_4^{2-}$
- C  $\text{Ba}^{2+}$  and  $\text{Cl}^-$
- D  $\text{Ba}^{2+}$  and  $\text{SO}_4^{2-}$ .



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



The monomer used to make this polymer is

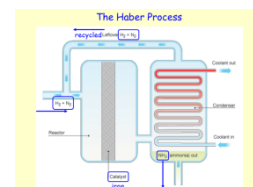
- A  $\begin{array}{c} H & H \\ | & | \\ C & = & C \\ | & | \\ CH_3 & H \end{array}$
- B  $\begin{array}{c} H & H \\ | & | \\ -C & - & C- \\ | & | \\ CH_3 & H \end{array}$
- C  $\begin{array}{c} H & H & H \\ | & | & | \\ C & = & C & - & C & - & H \\ | & & | & & | \\ CH_3 & & CH_3 \end{array}$
- D  $\begin{array}{c} H & H & H \\ | & | & | \\ -C & - & C & - & C- \\ | & | & | \\ CH_3 & H & CH_3 \end{array}$

- 10.

Which of the following solutions would produce a precipitate when mixed together?  
You may wish to use the data booklet to help you.

- A Ammonium chloride and potassium nitrate
- B Zinc nitrate and magnesium sulfate
- C Calcium nitrate and nickel chloride
- D Sodium iodide and silver nitrate

The table shows the colours of some ionic compounds in solution.



11.

Compound	Colour
copper sulfate	blue
copper chromate	green
potassium chloride	colourless
potassium chromate	yellow

The colour of the chromate ion is

- A blue
- B green
- C colourless
- D yellow.

12.

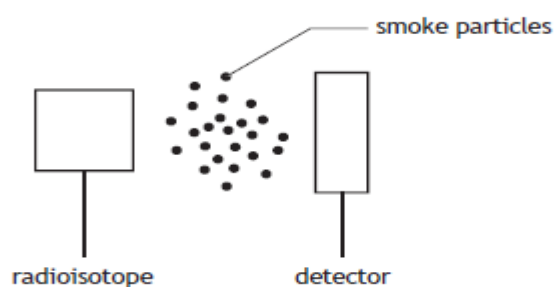
Which of the following metals can be obtained from its ore by heating with carbon monoxide?

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

- A Magnesium
- B Aluminium
- C Calcium
- D Nickel

13.

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



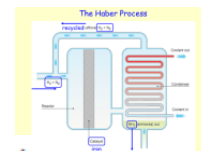
The most suitable type of radioisotope for a smoke detector would be

- 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.

14.

Which particle will be formed when an atom of  $^{234}_{90}\text{Th}$  emits a  $\beta$ -particle?

- A  $^{234}_{91}\text{Pa}$
- B  $^{230}_{88}\text{Ra}$
- C  $^{234}_{89}\text{Ac}$
- D  $^{238}_{92}\text{U}$



15.  $^{14}C$  has a half life of 5600 years. An analysis of charcoal from a wood fire shows that its  $^{14}C$  content is 25 % of that in living wood.

How many years have passed since the wood for the fire was cut?

- A 1400
- B 4200
- C 11 200
- D 16 800

16. A solution of potassium carbonate, made up using tap water, was found to be cloudy. This could result from the tap water containing

- A lithium ions
- B calcium ions
- C sodium ions
- D ammonium ions.

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

17. 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

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

- A Oxygen
- B Nitrogen
- C Potassium
- D Phosphorus

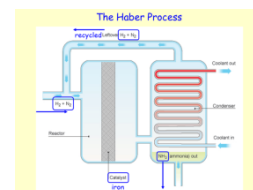
19. The Haber process is the industrial process for the manufacture of

- A nitric acid
- B ammonia
- C alkenes
- D esters.

Which of the following salts can be prepared by a precipitation reaction?

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

- A Barium sulfate
- B Lithium nitrate
- C Calcium chloride
- D Ammonium phosphate



21. A solution of accurately known concentration is more commonly known as a

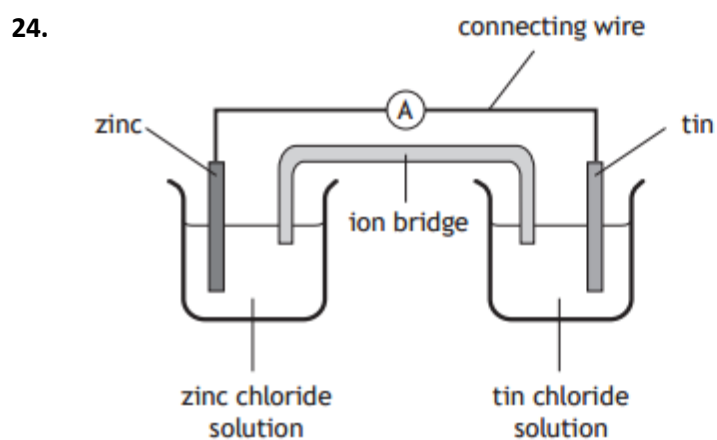
- A correct solution
- B precise solution
- C standard solution
- D prepared solution.

22. Which of the following substances does **not** produce water when it reacts with dilute acid?

- A Sodium hydroxide
- B Magnesium
- C Copper oxide
- D Ammonia solution

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

- A Aluminium
- B Zinc
- C Gold
- D Iron

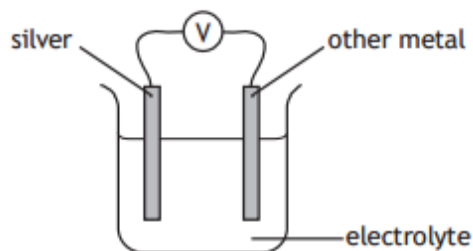
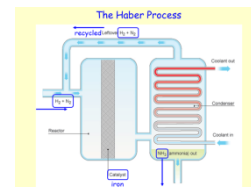


In the cell shown above, electrons flow through

- 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.



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



The voltages for the four cells are shown in the table.

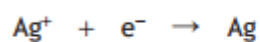
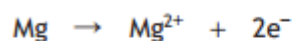
Which cell contained silver joined to copper?

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

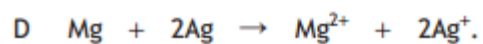
Cell	Voltage (V)
A	1.6
B	1.2
C	0.9
D	0.5

- 26.

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

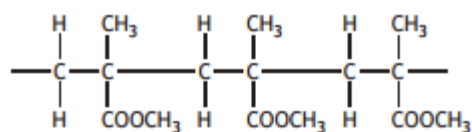


The overall redox equation is



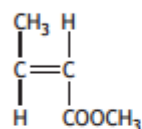
27.

The structure below shows a section of an addition polymer.

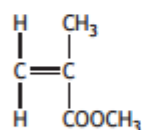


Which of the following molecules is used to make this polymer?

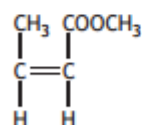
A



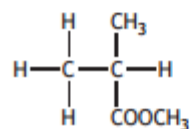
B



C



D



28.

Hydrogen gas

- A burns with a pop
- B relights a glowing splint
- C turns damp pH paper red
- D turns limewater cloudy.

29.

Sodium sulfate solution reacts with barium chloride solution.

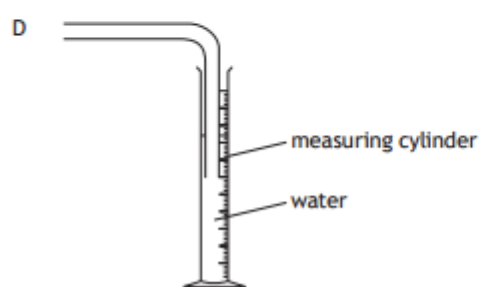
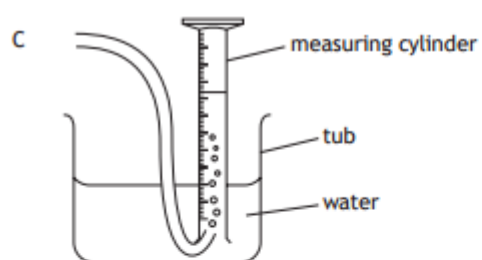
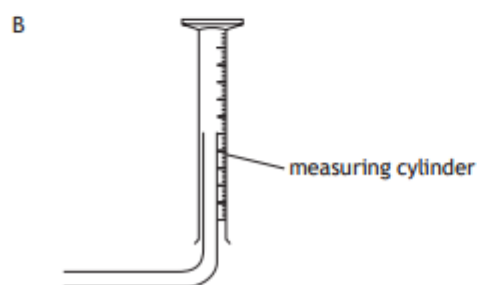
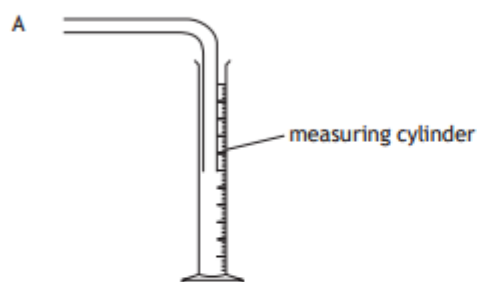


The spectator ions present in this reaction are

- A  $\text{Ba}^{2+}$  and  $\text{Cl}^-$
- B  $\text{Ba}^{2+}$  and  $\text{SO}_4^{2-}$
- C  $\text{Na}^+$  and  $\text{Cl}^-$
- D  $\text{Na}^+$  and  $\text{SO}_4^{2-}$

30. But-1-ene is a colourless, insoluble gas which is more dense than air but less dense than water.

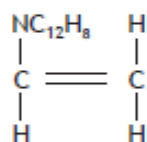
Which of the following diagrams shows the most appropriate apparatus for collecting and measuring the volume of but-1-ene?



## Section 2

1. Poly(vinylcarbazole) is a plastic which conducts electricity when exposed to light.

The structure of the monomer used to make poly(vinylcarbazole) is

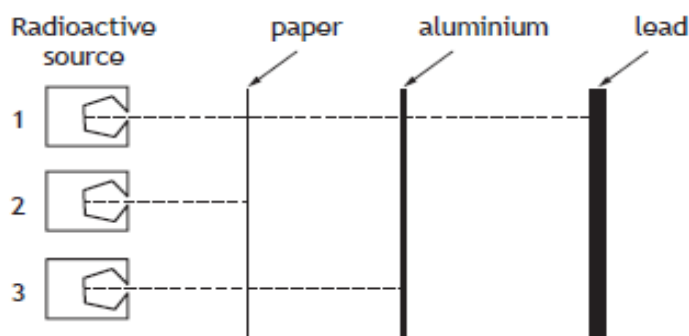


- (a) Draw a section of the polymer showing three monomer units joined together. 1

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

2. 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.

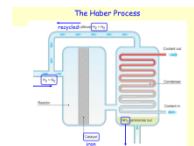
- (c) Radioisotopes can be made by scientists.

The nuclear equation shows how a radioisotope of element X can be made from aluminium.



Name element X. 1

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

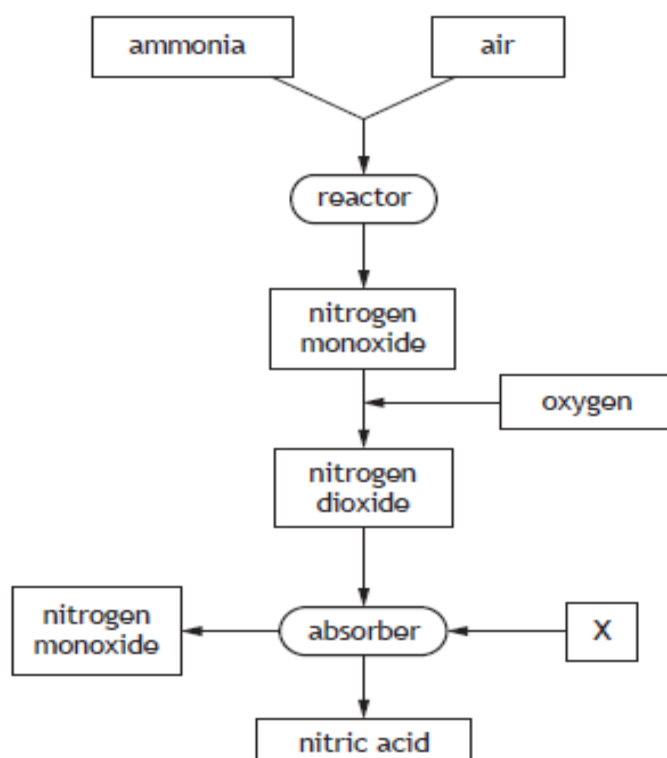


- (a) (i) In stage 1, ammonia is produced.

Name the industrial process used to manufacture ammonia.

1

- (b) In stage 2, ammonia is converted into nitric acid,  $\text{HNO}_3$ , 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

- (c) In stage 3, nitric acid is converted to potassium nitrate.

The equation for the reaction taking place is



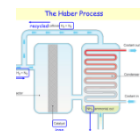
- (i) Name the type of chemical reaction taking place in stage 3.

1

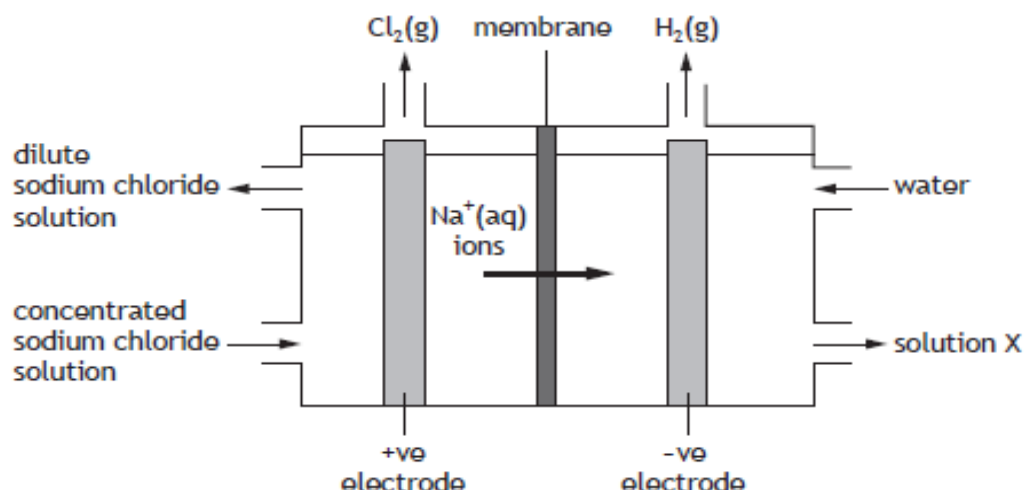
- (ii) State how a sample of solid potassium nitrate could be obtained from the potassium nitrate solution.

1

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.



4.



- (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

5.

Ores are naturally occurring compounds from which metals can be extracted.

- (a) When a metal is extracted from its ore, metal ions are changed to metal atoms.

Name this type of chemical reaction.

1

- (b) Iron can be extracted from its ore haematite,  $\text{Fe}_2\text{O}_3$ , in a blast furnace.

Calculate the percentage by mass of iron in haematite.

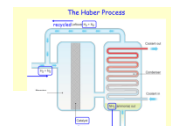
3

Show your working clearly.

- (c) Magnesium cannot be extracted from its ore in a blast furnace.

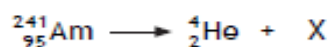
Suggest a method that would be suitable for the extraction of magnesium from its ore.

1



6. Americium-241, a radioisotope used in smoke detectors, has a half-life of 432 years.

(a) The equation for the decay of americium-241 is



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.

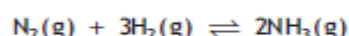
(i) A sample of americium-242 has a mass of 8 g.

Calculate the mass, in grams, of americium-242 that would be left after 48 hours.

2

Show your working clearly.

7. A researcher investigated the conditions for producing ammonia.



(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 °C.

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.

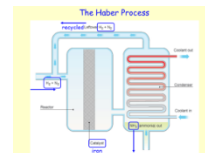
Temperature (°C)	200	300	400	500
Percentage yield (%)	89	67	39	18

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

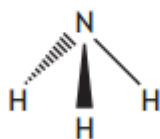
1

Nitrogen can form bonds with other elements.

The diagram shows the shape of a molecule of ammonia ( $\text{NH}_3$ ).



8.



- (i) State the name used to describe the shape of a molecule of ammonia.

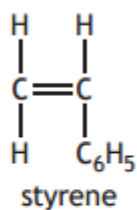
1

- (ii) Name the industrial process used to manufacture ammonia.

1

The monomer used to produce polystyrene has the following structure.

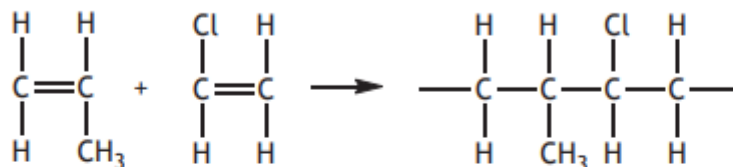
9.



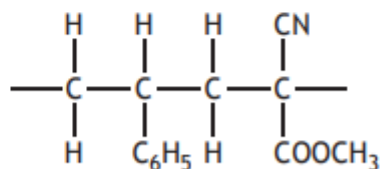
- (a) Draw a section of polystyrene, showing three monomer units joined together.

1

- (b) When two different monomers polymerise, a copolymer is formed as shown.



Another copolymer can be made from styrene and acrylonitrile monomers. A section of this copolymer is shown below.



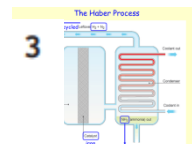
Draw the structure of the acrylonitrile monomer.

1



- (b) Calculate the percentage mass of silicon in andalusite,  $\text{Al}_2\text{SiO}_5$ .

3



10. Show your working clearly.

potassium.

11. (i) Suggest an experimental test, including the result, to show that potassium is present in the fertiliser. 1

- (ii) Ammonium citrate is included in the fertiliser because some phosphorus compounds are more soluble in ammonium citrate solution than they are in water.

Suggest another reason why ammonium citrate is added to the fertiliser. 1

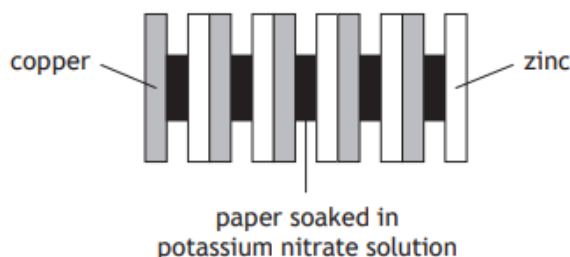
- (b) In the production of the fertiliser ammonium phosphate, phosphoric acid ( $\text{H}_3\text{PO}_4$ ) reacts with ammonium hydroxide as shown.



Balance this equation. 1

12. A battery is a number of cells joined together.

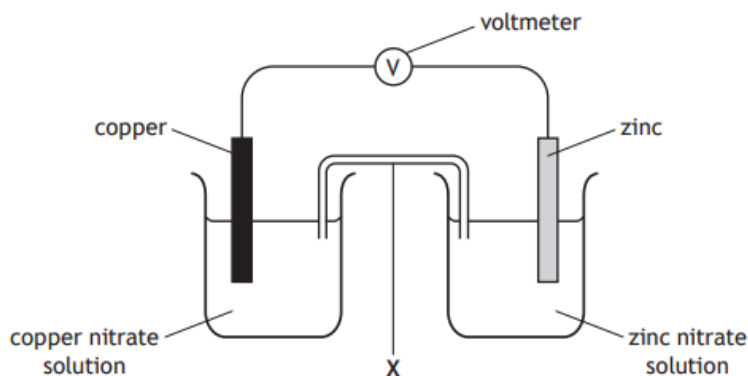
- (a) The diagram shows a simple battery made from copper and zinc discs separated by paper soaked in potassium nitrate solution.



The purpose of the potassium nitrate solution is to complete the circuit.

State the term used to describe an ionic compound which is used for this purpose. 1

- (b) A student set up a cell using the same metals as those used in the battery.



- (i) On the diagram, draw an arrow to show the path and direction of electron flow. 1

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

- (ii) Name the piece of apparatus labelled X. 1

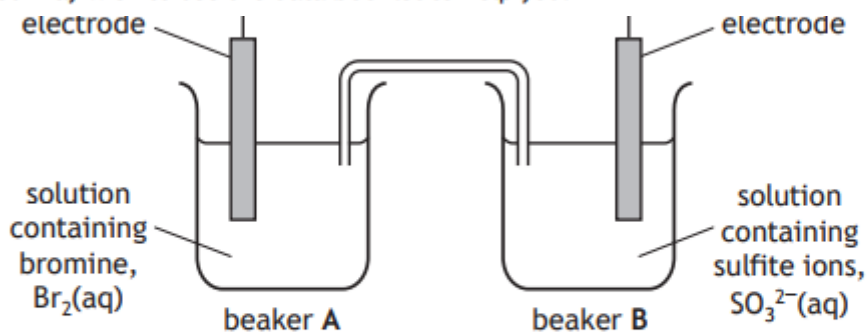
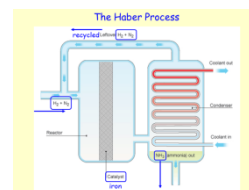
- (b) Rusting occurs when iron is exposed to air and water.

During rusting, iron initially loses two electrons to form iron(II) ions. These ions are further oxidised to form iron(III) ions.

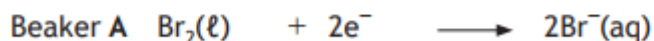
Write an ion-electron equation to show iron(II) ions forming iron(III) ions.

1

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



The reactions occurring at each electrode are



- (i) Name the type of chemical reaction taking place in beaker B.

1

- (ii) Write the redox equation for the overall reaction.

1

- (iii) Name a non-metal element which is suitable for use as the electrodes.

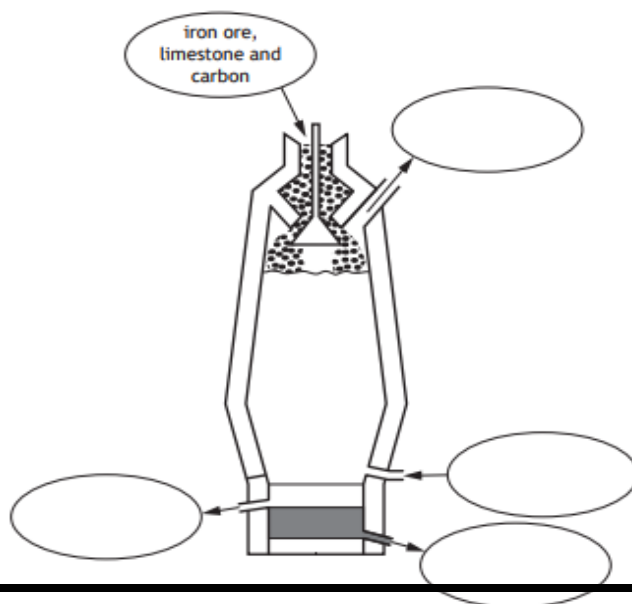
1

Iron is produced from iron ore in a blast furnace.

13. (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.

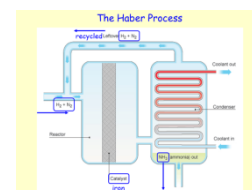
2



- (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.

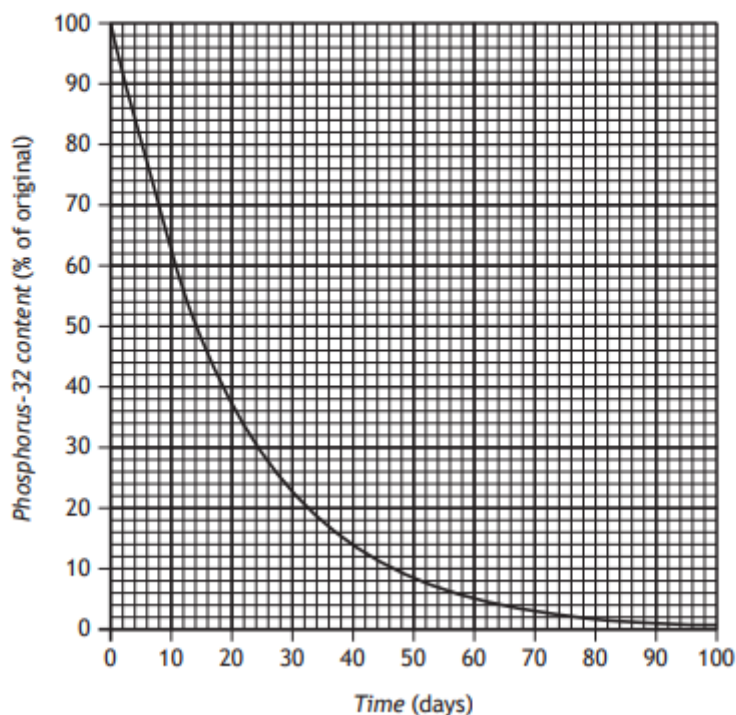


14.

Phosphorus-32 is a radioisotope used in the detection of cancerous tumours.

MARKS

- (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.

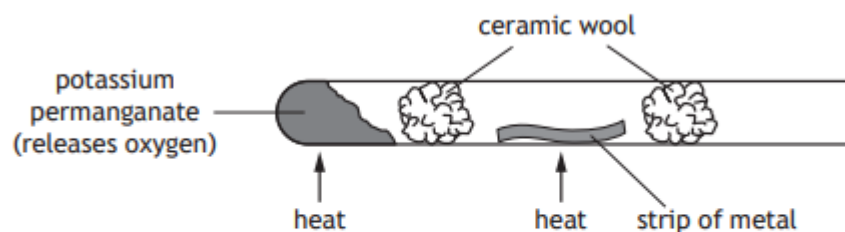
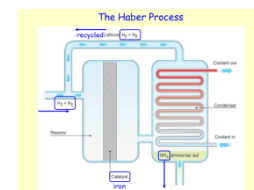
During this decay the atomic number increases by 1.

Name the type of radiation emitted when phosphorus-32 decays.

1

15.

A teacher demonstrated the following experiment.



The results are shown in the table.

<i>Metal</i>	<i>Observation</i>
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.

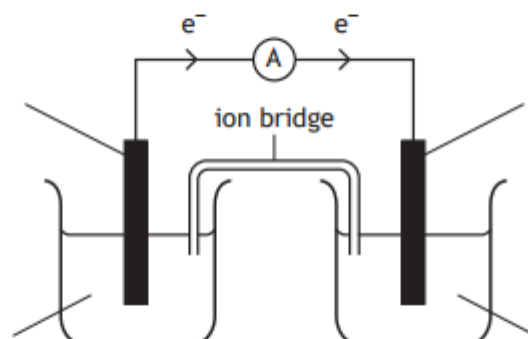
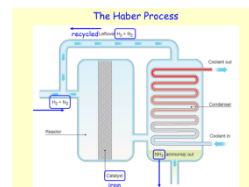


Identify the substance which is being oxidised.

1

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

16. (a) (i) Complete the labels on the diagram to show the electrochemical cell which would give the direction of electron flow indicated.  
You may wish to use the data booklet to help you.  
(An additional diagram, if required, can be found on *Page 27*.)



- (ii) The two reactions which take place in the cell are



Write the redox equation for the overall reaction.

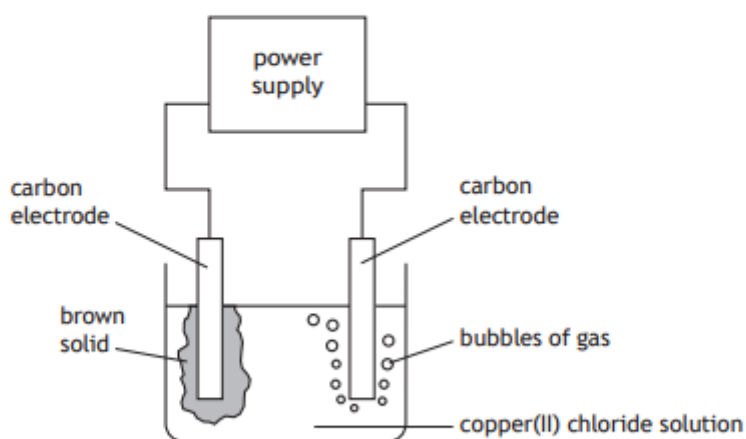
1

17 Metals can be extracted from metal compounds by electrolysis.

- (a) During electrolysis, metal ions are changed to metal atoms.  
Name this type of chemical reaction.

1

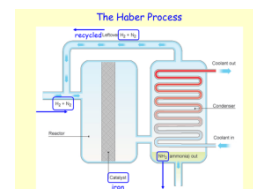
- (b) A student set up the following experiment to electrolyse copper(II) chloride solution.



- (ii) Complete the table by adding the charge on each electrode.

1

Observation at the _____ electrode	Observation at the _____ electrode
brown solid formed	bubbles of gas



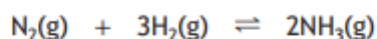
18. Urea,  $\text{H}_2\text{NCONH}_2$ , can be used as a fertiliser.

(a) Calculate the percentage of nitrogen in urea.

3

(b) Other nitrogen based fertilisers can be produced from ammonia.

Ammonia is produced in an industrial process using a catalyst.



(i) Name the industrial process that produces ammonia.

1

(ii) Suggest why a catalyst may be used in an industrial process.

1

(c) In another industrial process, ammonia is used to produce nitric acid.

Name the catalyst used in this process.

1

19. In medicine, technetium-99m is injected into the body to detect damage to heart tissue.

It is a gamma-emitting radioisotope with a half-life of 6 hours.

(a) A sample of technetium-99m has a mass of 2 g.

Calculate the mass, in grams, of technetium-99m that would be left after 12 hours.

2

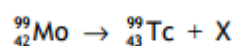
Show your working clearly.

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

1

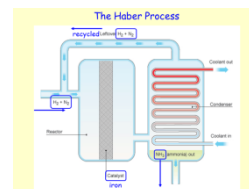
(c) Technetium-99m is formed when molybdenum-99 decays.

The decay equation is:



Identify X.

1



20.

**MARKS**

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

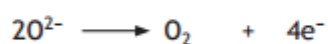
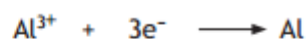
- (a) State the term used to describe naturally occurring metal compounds such as bauxite.

**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



- (i) Write the redox equation for the overall reaction.

**1**

- (ii) State why ionic compounds, like aluminium oxide, conduct electricity when molten.

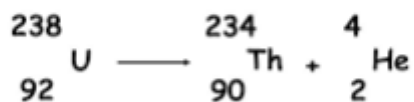
**1**

# National 5 Chemistry

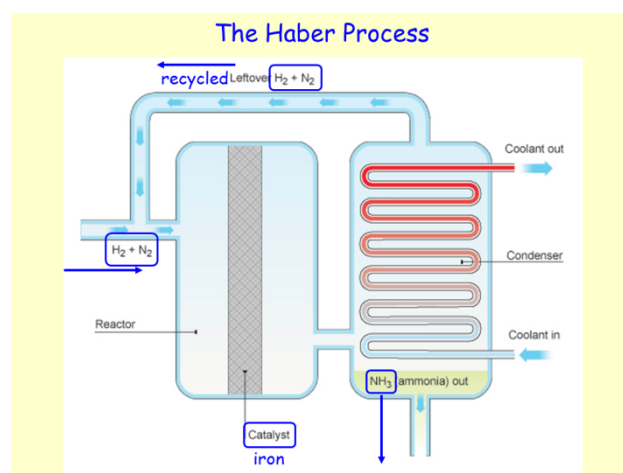
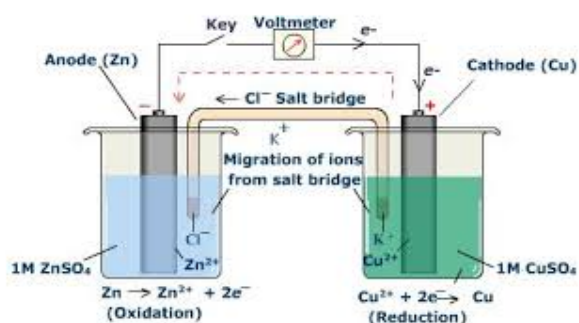
## Unit 3 Past Paper Questions Answers

### Nuclear Equations

*Mass numbers:  $234 + 4 = 238$*



*Atomic numbers:  $90 + 2 = 92$*

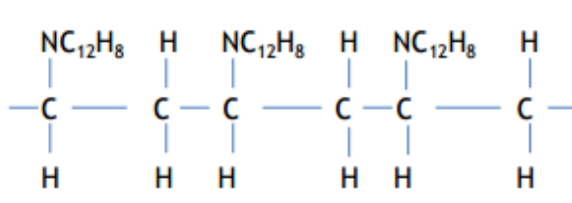




## **Section 1 Answers**

<b>1</b>	<b>A</b>	<b>11</b>	<b>D</b>	<b>21</b>	<b>C</b>
<b>2</b>	<b>D</b>	<b>12</b>	<b>D</b>	<b>22</b>	<b>B</b>
<b>3</b>	<b>B</b>	<b>13</b>	<b>A</b>	<b>23</b>	<b>C</b>
<b>4</b>	<b>B</b>	<b>14</b>	<b>A</b>	<b>24</b>	<b>D</b>
<b>5</b>	<b>D</b>	<b>15</b>	<b>C</b>	<b>25</b>	<b>D</b>
<b>6</b>	<b>C</b>	<b>16</b>	<b>B</b>	<b>26</b>	<b>A</b>
<b>7</b>	<b>D</b>	<b>17</b>	<b>C</b>	<b>27</b>	<b>B</b>
<b>8</b>	<b>A</b>	<b>18</b>	<b>A</b>	<b>28</b>	<b>A</b>
<b>9</b>	<b>A</b>	<b>19</b>	<b>B</b>	<b>29</b>	<b>C</b>
<b>10</b>	<b>D</b>	<b>20</b>	<b>A</b>	<b>30</b>	<b>C</b>

## Section 2 Answers

Question	Answer	Max Mark	Additional Guidance
1.			
(a)	 <p>With or without brackets.</p> <p>The bond to NC<sub>12</sub>H<sub>8</sub> does not need to be drawn to the nitrogen but must be drawn to the group.</p>	1	<p>Award mark if <b>one</b> end bond is missing</p> <p>Award mark if one end bond is shown with other end having a H in place of second end bond</p> <p>Allow dot or ~ to represent end bond</p> <p>Zero marks if <b>both</b> end bonds are missing / both ends have H / less than or more than three monomers shown / bond between two carbon missing</p>
(b)	Addition or additional	1	<p>Do not award mark for “adding”</p> <p>Mention of condensation negates correct answer</p>
2.			
(a)	alpha or $\alpha$	1	<p><math>{}^4_2\text{He}</math> <math>{}^4_2\text{He}^{2+}</math> on their own not accepted but do not negate</p> <p>Any mention of beta or gamma negates correct answer</p>
(b)	<p><math>\frac{1}{4}</math> / 0.25 / 25% with no working (2)</p> <p>Two half-lives (1)</p> <p><math>\frac{1}{4}</math> or 0.25 or 25% (1)</p>	2	<p>If number of half lives is incorrect allow follow through to second step</p> <p>Incorrect answer with no working zero marks</p>
(c)	<p>Sodium / Na</p> <p><math>{}^{24}_{11}\text{Na}</math> <math>{}^{24}\text{Na}</math> <math>{}_{11}\text{Na}</math></p>	1	<p>If mass/atomic number given they must be correct</p> <p><math>{}^{24}_{11}\text{X}</math> chromium zero marks</p> <p><math>{}^{23}_{11}\text{Na}</math> zero marks</p>

3.

(a)	(i)	Haber	1	
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(b)	(i)	Water / H <sub>2</sub> O / Hydrogen oxide	1	
	(ii)	Arrow from nitrogen monoxide from absorber to nitrogen monoxide below reactor (anywhere below the reactor and above nitrogen dioxide)	1	Direction of arrow must be correct
(c)	(i)	Neutralisation	1	

	(ii)	Evaporation or boil it / boil off the water or distillation or correct description	1	<p>Filtration on its own is not acceptable</p> <p>It negates the correct answer if stated evaporation <b>OR</b> filtration/ evaporation and filtration/ filtration then leave to dry ( unless stated filtrate left to dry)</p> <p>It does <b>not</b> negate if stated filtration followed by evaporation</p> <p>Filtration then evaporation/ filtration followed by evaporation accepted.</p> <p>Filtration and evaporation zero marks.</p>
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4.	(a)	$2\text{Cl}^- \longrightarrow \text{Cl}_2 + 2\text{e}^-$ or $2\text{Cl}^- - 2\text{e}^- \longrightarrow \text{Cl}_2$	1	Ignore state symbols if given / state symbols not required  Do not need negative sign on electron  Negative sign must be shown on chloride ion
	(b) (i)	sodium hydroxide or sodium oxide	1	Accept correct formula If charges shown they must be correct

5.	(a)	Reduction	1	Redox - zero marks
	(b)	70 with no working (3)  GFM = 160g (1)  $112 / 160 \times 100$ (1)  = 70 (1)	3	If atomic numbers are used with working shown (68.4 %) maximum 2 marks  68.4 on its own - 0 marks  Allow follow through  If candidate correctly calculates percentage of oxygen (30%) rather than iron maximum 2 marks but working must be shown  30% on its own zero marks  Unit not required however if wrong unit given do not award mark for final answer.
	(c)	Electrolysis  Or correct description eg passing electricity through it	1	Electricity on its own is awarded zero marks  heating with carbon negates correct answer  heating negates the correct answer unless it is clear that this is used to melt the ore

6. (a)	Neptunium or Np  or  $^{237}_{93}\text{Np}$ $^{237}_{93}\text{Np}$ $^{93}_{93}\text{Np}$	1	If mass or atomic number are given incorrectly e.g. $^{236}_{93}\text{Np}$ $^{93}_{93}\text{Np}$ 0 marks  Do not penalise if the atomic number/mass number is written on the right hand side of the symbol.  NP or np or nP are awarded zero marks and negates (cancels) the correct name.
(b)	Alpha or $\alpha$ or $^4_2\alpha$	1	$^4_2\text{He}$ or $^4_2\text{He}^{2+}$ on their own they are not acceptable but if given with a correct answer they do not negate the correct answer.  Any mention of beta or gamma negates the correct answer eg Alpha $\beta$ award 0 marks
(c) (i)	1 with no working (2)  <hr/> Partial marking  Three half-lives stated or correct working shown (1)  Final answer = 1 (1) (this step on its own 2 marks)	2	If number of half-lives is incorrect allow follow through to second step - maximum 1 mark can be awarded.  Unit is not required however if the wrong unit is given a maximum of 1 mark out of 2 can be awarded.  A correct answer clearly derived from incorrect working is awarded zero marks.
(c) (ii)	(It/Americium 241/Am-241) has a long/longer half life  or  will not need to be replaced as often or words to this effect  or  (It/Americium 241/Am-241) emits alpha radiation (particles) which has a low penetrating power/doesn't travel far/stopped by the smoke particles.	1	If candidate states -shorter/short/lower half-life/needs replaced more often/does not last as long/only has a half-life of 16 hours it must be stated that they are referring to americium -242  Zero marks awarded for It/Am-241 has a half-life of 432 years or Am-242 has a half-life of 16 hours.  Socio-economical answers or answers relating to safety are not accepted but do not negate the correct answer. Refer to General Marking Principle (p) for guidance.

7.	(a)	Iron or Fe	1	Refer to General Marking Principle (m) for guidance.
	(b)	Any value from 52 - 56 inclusive	1	
	(c)	As temperature increases the yield decreases.  or  As temperature decreases the yield increases.  or  The yield increases as the temperature decreases.  or  The yield decreases as the temperature increases.  Accept percentage in place of yield.	1	Cause and effect must be stated correctly.  Zero marks awarded for  The temperature increases as the yield decreases.  or  As the yield increases the temperature decreases.  Accept alternatives to increases e.g. goes up/gets higher decreases e.g. goes down/gets lower/gets less
	(d)	temperature 200 °C or a value below 200 °C  and  pressure 500 atmospheres or a value greater than 500 atmospheres          Both required for 1 mark	1	Do not accept correct values without either unit or label. eg temperature 200 and 500 atmospheres is awarded 1 mark; 200 °C and pressure of 500 is awarded 1 mark.  The candidate must link each value given to the correct condition.  eg 500 and 200 - 0 marks; 500 atmospheres and 200 - 0 marks

8.

(c)	(i)	Pyramidal  OR  Trigonal pyramidal	1	Zero marks awarded for trigonal on its own.  Zero marks awarded for 'pyramid'.
	(ii)	Haber	1	

9.

(a)	<div style="text-align: center;"> <math display="block">  \begin{array}{cccccc}  \text{H} &amp; \text{H} &amp; \text{H} &amp; \text{H} &amp; \text{H} &amp; \text{H} \\    &amp;   &amp;   &amp;   &amp;   &amp;   \\  -\text{C} &amp; -\text{C} &amp; -\text{C} &amp; -\text{C} &amp; -\text{C} &amp; -\text{C}- \\    &amp;   &amp;   &amp;   &amp;   &amp;   \\  \text{H} &amp; \text{C}_6\text{H}_5 &amp; \text{H} &amp; \text{C}_6\text{H}_5 &amp; \text{H} &amp; \text{C}_6\text{H}_5  \end{array}  </math> </div> <p>With or without brackets</p>	<p>1</p> <p>Do not deduct mark if one end bond is missing.</p> <p>Do not deduct mark if one end bond is shown with other end having an H in place of second end bond.</p> <p>Allow dot or ~ to represent end bond.</p> <p>Zero marks awarded if both end bonds are missing/both ends have H/less than or more than three monomers shown/bond between two carbons missing.</p>
(b)	$  \begin{array}{cc}  \text{H} & \text{CN} \\    &   \\  \text{C} & = \text{C} \\    &   \\  \text{H} & \text{COOCH}_3  \end{array}  $	<p>1</p> <p>Zero marks awarded if candidate draws <b>both monomers</b>, unless they have clearly identified the acrylonitrile monomer.</p>

10.

(b)	<p>17 or 17.28 or 17.3 with no working 3 marks</p> <hr/> <p>GFM 162 (1)</p> <p>28/162 × 100 (concept mark) (1) This step on its own 2 marks</p> <p>1 mark for correct arithmetic to give final answer (this mark can only be awarded if the concept mark has been awarded).</p>	<p>3</p> <p>Maximum 2 marks if candidate correctly calculates percentage of aluminium (33 or 33.3 %) or oxygen (49 or 49.38 or 49.4 %) rather than silicon but <b>working must be shown</b>.</p> <p>Maximum 2 marks if atomic numbers are used (17.5 % of silicon) but <b>working must be shown</b>.</p> <p>If candidate incorrectly rounds to 17.2 then a maximum of 2 marks can be awarded only if working is shown.</p> <p>If value divided by 162 does not correspond to an element in the compound award a maximum of 1 mark.</p> <p>Unit is not required however if the wrong unit is given do not award final mark.</p>
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11.

(a)	(i)	Flame test or correct description e.g. burn it/fertiliser/potassium, put in Bunsen flame etc.  <b>AND</b>  purple/lilac  <b>Both required</b>	1	Mention of burning the plant negates correct answer.
	(ii)	To add/provide/supply nitrogen or it contains nitrogen.  Any wording that implies that plants need nitrogen.	1	Zero marks awarded for 'essential/key element' on its own but does <b>not</b> negate correct answer.  Zero marks awarded for 'to make plants grow better' on its own but does <b>not</b> negate correct answer.
(b)		$\text{H}_3\text{PO}_4 + 3\text{NH}_4\text{OH} \rightarrow (\text{NH}_4)_3\text{PO}_4 + 3\text{H}_2\text{O}$  If rewritten accept  $  \begin{array}{ccc}  \text{H}_3\text{PO}_4 & + & 3\text{NH}_4\text{OH} \\  & \downarrow & \\  (\text{NH}_4)_3\text{PO}_4 & + & 3\text{H}_2\text{O}  \end{array}  $	1	Accept correct multiples  If equation is rewritten, <b>all</b> formulae must be correct and correct format see marking instructions for Question 10c(ii).  If state symbols are given they must be correct.

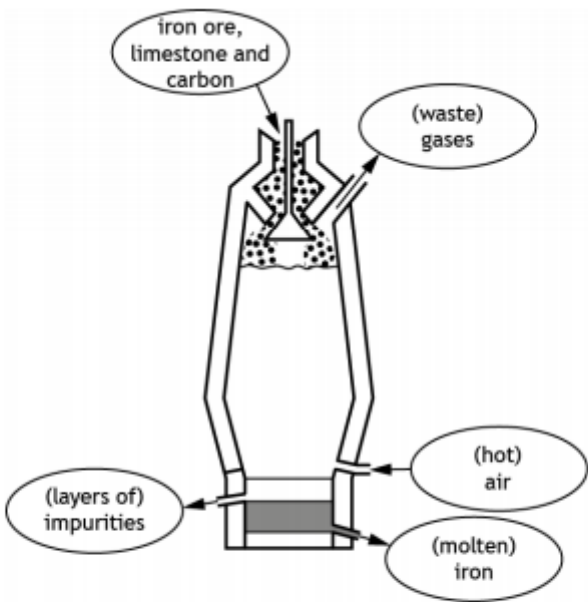
12.

(a)		Electrolyte	1	
(b)	(i)	From zinc to copper on or near the wire/voltmeter	1	Zero marks awarded if – arrow goes into solution – arrow is drawn on wire and ion bridge – arrow is drawn closer to the ion bridge than the wire / voltmeter
	(ii)	Ion bridge  <b>OR</b>  Salt bridge	1	Correct description of an ion bridge eg filter paper soaked in an electrolyte.
(c)	(i)	Oxidation	1	Zero marks awarded for redox.



(ii)	$\text{Br}_2(\text{l}) + \text{SO}_3^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \longrightarrow 2\text{Br}^-(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) + 2\text{H}^+(\text{aq})$ <p><b>OR</b></p> $\text{Br}_2(\text{l}) + \text{SO}_3^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l})$ $\downarrow$ $2\text{Br}^-(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) + 2\text{H}^+(\text{aq})$ <p style="text-align: right;"><b>1</b></p> <p>State symbols are not required but if included must be correct.</p> <p>Zero marks awarded for any electrons shown in equation, unless clearly scored out.</p> <p>Zero marks awarded for</p> $\text{Br}_2(\text{l}) + \text{SO}_3^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \longrightarrow$ $2\text{Br}^-(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) + 2\text{H}^+(\text{aq})$
(iii)	<div style="display: flex; justify-content: space-between;"> <div>Carbon or graphite</div> <div style="text-align: center;"> <b>1</b> </div> <div>           Zero marks awarded for hydrogen, diamond or charcoal and these negate a correct answer.         </div> </div>

13.

(a)	<div style="display: flex;"> <div style="flex: 1;"> <p>(i)</p> </div> <div style="flex: 2; text-align: center;">  </div> </div> <div style="display: flex; justify-content: space-between; margin-top: 20px;"> <div></div> <div style="text-align: center;"> <b>2</b> </div> <div>           All 4 correct - 2 marks             2/3 correct - 1 mark             0/1 correct - 0 marks         </div> </div>
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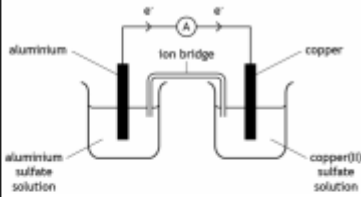
	(ii)	Iron would not melt/ be molten/liquid or able to flow  or  Iron would be solid  or  Iron needs to be molten/liquid/flowing	1	Award zero marks for: -it is the melting point of iron however, this does not negate a correct answer.
(b)		$\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + \text{e}^-$  or  $\text{Fe}^{2+} - \text{e}^- \rightarrow \text{Fe}^{3+}$	1	State symbols are not required however, if given they must be correct

14.

(a)	(i)	14 (days)	1	No units required but no mark is awarded if wrong unit is given. (Wrong units are only penalised once in any paper).
	(ii)	42 (days) (2) <hr/> Partial marking 3 half-lives (1)  or  Correct number of days for an incorrect number of half-lives-working must be shown. (1)	2	Allow follow through from part (a)(i) to allow the candidate to access both marks  No units required but maximum of 1 mark is awarded if wrong unit is given. (Wrong units are only penalised once in any paper).
(b)		beta  or  $\beta$  or  ${}^0_{-1}\beta$  or  ${}^0_{-1}\text{e}$	1	

15.	(a)	(i)	Glowed brighter/more brightly than zinc  or  Glowed most brightly/very brightly/white light	1	
		(ii)	Faster/higher/speed up/increase	1	Award zero marks for -takes less time on its own but does not negate correct answer.
	(b)		Magnesium  or  Mg	1	Can be circled, highlighted etc

16.

(a)	(i)	 <p>ALL REQUIRED FOR 1 MARK</p>	1	Accept - copper sulfate instead of copper(II) sulfate - name of solution without (aq) or solution.
	(ii)	$3\text{Cu}^{2+} + 2\text{Al} \rightarrow 3\text{Cu} + 2\text{Al}^{3+}$	1	Accept correct multiples  Zero marks awarded for -electrons shown in equation, unless clearly scored out.  State symbols are not required however if given they must be correct

17.

(a)		reduction	1	
(b)	(i)	d.c.	1	
	(ii)	Negative - (brown solid formed) Positive - (bubbles of gas)	1	Both required for one mark

18.

(a)		46.67 / 46.7 / 47 (3) <hr/> Partial marking: <i>GFM</i> = 60 (1)  $\frac{28}{\text{candidate's } GFM} \times 100 \text{ (1)}$  Calculation of final answer using the relationship $\% \text{ by mass} = \frac{m}{GFM} \times 100 \text{ (1)}$	3	
(b)	(i)	Haber (-Bosch)	1	
	(ii)	Speeds up reaction or Less energy/temperature/ heat required	1	
(c)		platinum	1	Accept platinum and rhodium (allow)

19.

(a)	<p>0.5 (g) (2)</p> <hr/> <p>Partial marking:</p> <p>1 mark can be awarded for either:</p> <ul style="list-style-type: none"> <li>• 2 half lives</li> </ul> <p>or</p> <ul style="list-style-type: none"> <li>• mass correctly calculated for an incorrect number of half-lives shown.</li> </ul>	2	Units are not required but a maximum of 1 mark can be awarded for the correct answer if incorrect unit is given.
(b)	<p>short half-life</p> <p>or</p> <p>would not last long in the body</p> <p>or</p> <p>gamma would go right through body</p> <p>or</p> <p>equivalent response</p>	1	
(c)	<p>beta / <math>\beta</math> / <math>{}^0_{-1}\text{e}</math> / <math>{}^0_{-1}\beta</math></p>	1	<p>The charge on the beta particle does not need to be shown.</p> <p>Do not accept electron without atomic and mass numbers, ie e or e<sup>-</sup></p>

20.

(a)		(Metal) ore/ores	1	Zero marks awarded for mineral/alloy These also negate the correct answer. Refer to General Marking Principle (f) for guidance.
(b)	(i)	$4\text{Al}^{3+} + 6\text{O}^{2-} \rightarrow 4\text{Al} + 3\text{O}_2$ (or correct multiples) <b>All must be correct for 1 mark</b>	1	Zero marks awarded for any electrons shown in equation.  Ignore state symbols if given.
	(ii)	ions free to move or ions able to move or ions mobile	1	Any mention of electrons negates the correct answer. Refer to General Marking Principle (g) for guidance.  The word 'ion' must be mentioned.  Zero marks awarded for they can move or (charged) particles or molecules or electrons can move.
(c)		Mg or magnesium or 2Mg or Mg circled/highlighted/underlined in equation.	1	Any other substance indicated, in addition to Mg, negates the correct answer. Refer General Marking Principle (g) for guidance.