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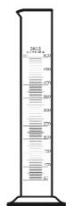
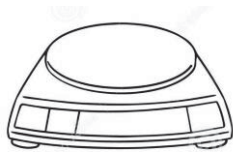
- 1 The diagram shows four pieces of laboratory apparatus.

electronic balance

measuring cylinder

stop watch

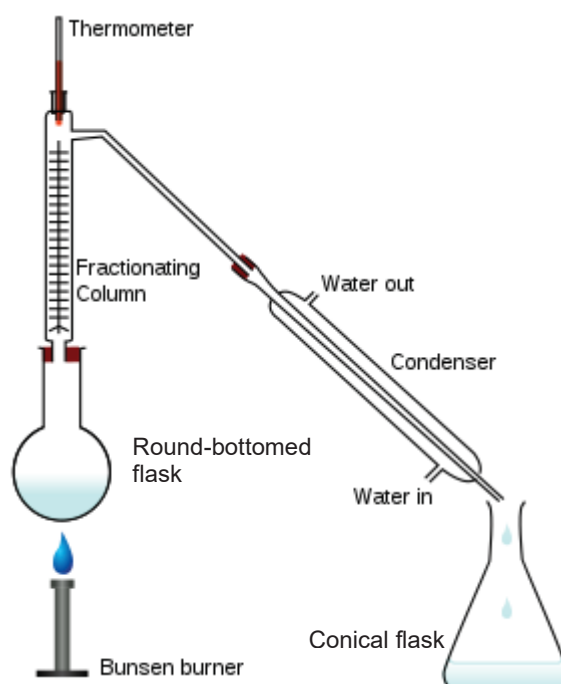
thermometer



Which apparatus is/are essential to find out if dissolving a salt in water is an endothermic process?

	electronic balance	measuring cylinder	stop watch	thermometer
<b>A</b>	X	X	X	✓
<b>B</b>	✓	X	X	✓
<b>C</b>	X	✓	X	✓
<b>D</b>	✓	✓	✓	X

- 2 Equal volumes of two liquids to be separated are placed in the apparatus below.



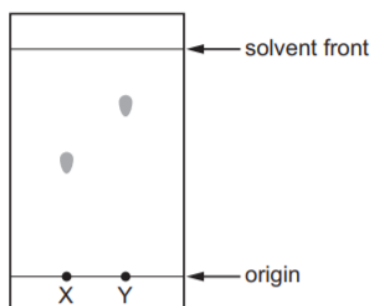
The purity of each liquid collected can be improved by

- A** adding boiling chips into the round-bottomed flask
- B** using a longer condenser
- C** using a longer fractionating column
- D** stoppering the conical flask

- 3 The results of a paper chromatography experiment are shown.

X is an aqueous solution of a salt of a Group I element.

Y is an aqueous solution of a salt of a transition element.



Which row is correct?

	larger $R_f$ value	requires a locating agent
<b>A</b>	X	X
<b>B</b>	X	Y
<b>C</b>	Y	X
<b>D</b>	Y	Y

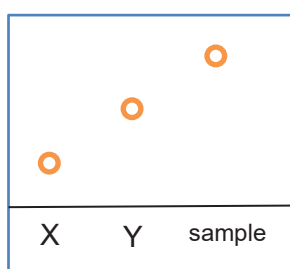
- 4 An organic chemist attempts to synthesise a new fragrance (a compound) by the following chemical reaction.



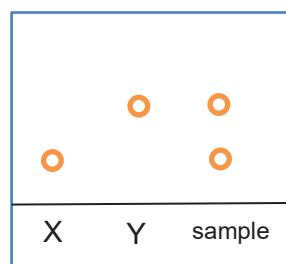
After one hour, a sample of the fragrance is removed and compared with pure samples of compounds X and Y using paper chromatography.

Which chromatogram shows that the reaction has produced a pure sample of the fragrance?

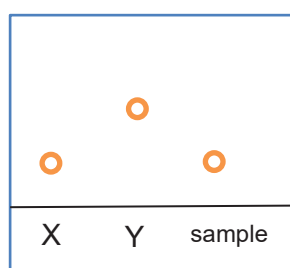
**A**



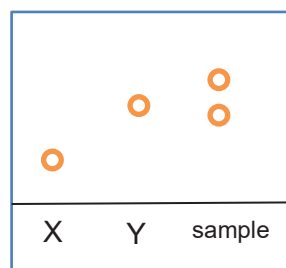
**B**



**C**



**D**



- 5 A chemist wants to obtain hexane (boiling point 68 °C) from a mixture of hexane and water. What is the best method to use?

A fractional distillation  
 B paper chromatography  
 C separating funnel  
 D simple distillation

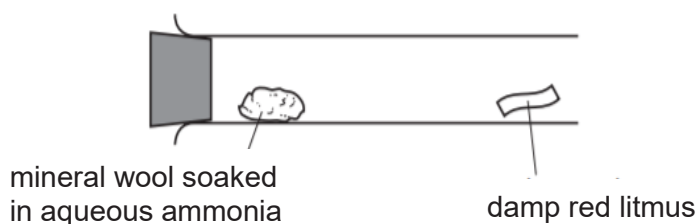
- 6 The table gives data about four substances.

	melting point / °C	boiling point / °C
W	-182	-162
X	-112	-108
Y	-7	59
Z	39	688

When the ambient temperature is cooled to -110 °C, which substance(s) has/have particles in a disorderly arrangement?

A W only  
 B W and X  
 C Y and Z  
 D W, X and Y

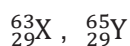
- 7 Mineral wool soaked in aqueous ammonia is placed in the apparatus shown.



After five minutes, the damp red litmus paper turned blue. Which process led to this change?

A crystallisation  
 B condensation  
 C diffusion  
 D sublimation

- 8 The nuclide notations for two atoms are given below, along with two possibly correct statements.



Statement 1: Both atoms are isotopes of copper.

Statement 2: Both atoms have variable oxidation states.

Which of the following is correct?

A Both statements are correct and statement 2 explains statement 1.  
 B Both statements are correct but statement 2 does not explain statement 1.  
 C Statement 1 is correct but statement 2 is incorrect.  
 D Statement 2 is correct but statement 1 is incorrect.

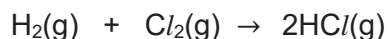


- 13 An element, E, forms a hydride,  $\text{EH}_4$ , which contains 90% by mass of E.

Find the relative atomic mass of E.

- A 9                      B 36                      C 86                      D 90

- 14  $50 \text{ cm}^3$  of hydrogen is mixed with  $25 \text{ cm}^3$  of chlorine. The gases react as shown in the equation below.



What is the total volume of gas present at the end of the reaction?

- A  $50 \text{ cm}^3$               B  $75 \text{ cm}^3$               C  $100 \text{ cm}^3$               D  $125 \text{ cm}^3$

- 15 What is the total number of electrons and protons in one mole of hydrogen gas?

- A 2    B 4  
C  $1.2 \times 10^{24}$                               D  $2.4 \times 10^{24}$

- 16 The table gives information about three indicators.

indicator	colour change		pH at which colour change takes place
	low pH	high pH	
methyl orange	red	yellow	4.0
bromothymol blue	yellow	blue	6.5
phenolphthalein	colourless	pink	9.0

If equal volumes of these three indicators were mixed, which colour would be observed at pH 5?

- A blue  
B green  
C orange  
D yellow

- 17 Which of the following is the same for  $1 \text{ mol/dm}^3$  of hydrochloric acid and  $1 \text{ mol/dm}^3$  of ethanoic acid?

- 1 electrical conductivity  
2 volume of sodium hydroxide for neutralisation

- A 1 only  
B 2 only  
C both 1 and 2  
D neither 1 nor 2

18 How many barium salts can be obtained by the following preparation methods?

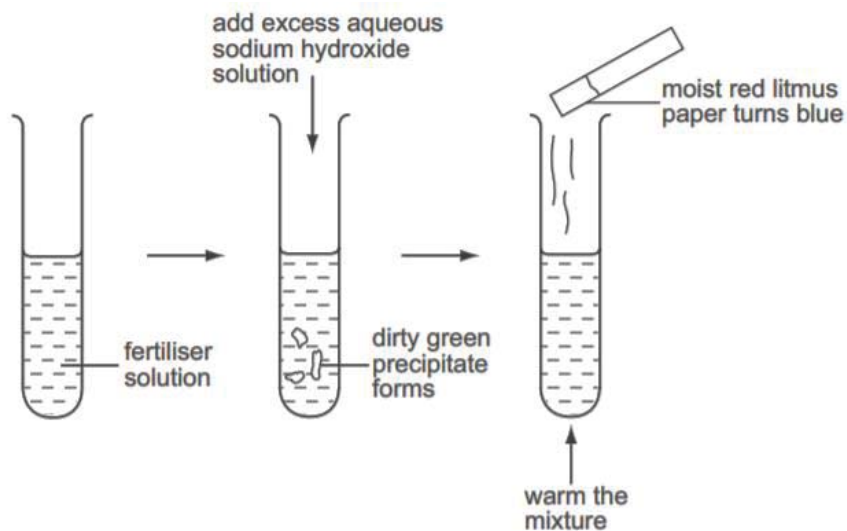
- addition of aqueous barium nitrate to aqueous sodium chloride
- addition of excess barium carbonate to hydrochloric acid
- addition of excess barium oxide to sulfuric acid
- titration of aqueous barium hydroxide with hydrochloric acid

A 1                      B 2                      C 3                      D 4

19 A white crystalline solid is dissolved in distilled water. A small amount of dilute nitric acid is added followed by aqueous silver nitrate. No visible change occurs. What can be deduced about the white crystalline solid?

- A It contains chloride ions.  
 B It contains bromide ions.  
 C It does not contain carbonate ions.  
 D It must contain sulfate ions.

20 A solution of fertiliser was tested as shown.



Which ions must be present in the fertiliser?

- A  $\text{NH}_4^+$  and  $\text{NO}_3^-$   
 B  $\text{NH}_4^+$  and  $\text{Fe}^{2+}$   
 C  $\text{Fe}^{2+}$  and  $\text{NO}_3^-$   
 D  $\text{Fe}^{3+}$  and  $\text{NO}_3^-$

21 A gas, R, has the following properties:

- odourless and colourless
- no effect on damp litmus papers
- turns purple acidified potassium manganate(VII) colourless

What gas is R likely to be?

- A carbon dioxide
- B carbon monoxide
- C hydrogen sulfide
- D sulfur dioxide

22 Which of the following is the most powerful reducing agent?

- A bromine atom
- B chlorine atom
- C fluoride ion
- D iodide ion

23 Ammonium metavanadate,  $\text{NH}_4\text{VO}_3$ , can be used to make a solution containing  $\text{VO}_2\text{Cl}$ .

What is the change in the oxidation number of vanadium in this reaction?

- A -1                      B 0                      C +1                      D +2

24 Which equation shows hydrogen peroxide behaving as a reducing agent?

- A  $2\text{Fe}^{2+}(\text{aq}) + \text{H}_2\text{O}_2(\text{l}) + 2\text{H}^+(\text{aq}) \rightarrow 2\text{Fe}^{3+}(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$
- B  $2\text{I}^-(\text{aq}) + \text{H}_2\text{O}_2(\text{l}) + 2\text{H}^+(\text{aq}) \rightarrow \text{I}_2(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$
- C  $\text{MnO}_2(\text{s}) + \text{H}_2\text{O}_2(\text{l}) + 2\text{H}^+(\text{aq}) \rightarrow \text{Mn}^{2+}(\text{aq}) + 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$
- D  $\text{PbS}(\text{s}) + 4\text{H}_2\text{O}_2(\text{l}) \rightarrow \text{PbSO}_4(\text{s}) + 4\text{H}_2\text{O}(\text{l})$

25 Which equation represents a redox reaction?

- A  $\text{NaH}(\text{s}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{NaOH}(\text{aq}) + \text{H}_2(\text{g})$
- B  $\text{CaCO}_3(\text{s}) \rightarrow \text{CO}_2(\text{g}) + \text{CaO}(\text{s})$
- C  $\text{CuCl}_2(\text{aq}) + \text{K}_2\text{S}(\text{aq}) \rightarrow \text{CuS}(\text{s}) + 2\text{KCl}(\text{aq})$
- D  $\text{HCl}(\text{aq}) + \text{NH}_3(\text{aq}) \rightarrow \text{NH}_4\text{Cl}(\text{aq})$

26 Which statements are true about all the noble gases?

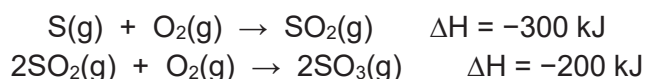
- 1 The melting point increases down the group.
- 2 They all have eight electrons in their outer shell.
- 3 They are coloured gases.
- 4 They are insoluble in water.

- A 1 and 2                      B 1 and 4  
C 2 and 3                      D 3 and 4

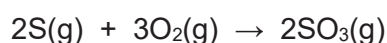
27 Selenium is an element in Group VI. Which statement about selenium is correct?

- A Selenium dioxide is a basic oxide.
- B Selenium disulfide has the formula  $\text{SeS}_2$ .
- C Selenium forms the ion  $\text{Se}^{2+}$  in compounds.
- D Selenium has a high melting point and boiling point.

28 The equations and enthalpy changes for two reactions used in the manufacture of sulfuric acid are



What is the enthalpy change, in kJ, for the reaction below?



- A -100
- B -400
- C -500
- D -800

29 An equation for a reaction in which hydrogen is formed is



Which energy change occurs when 1 mol of hydrogen is formed in this reaction?

- A 70 kJ of energy are absorbed from the surroundings.
- B 70 kJ of energy are released to the surroundings.
- C 210 kJ of energy are absorbed from the surroundings.
- D 210 kJ of energy are released to the surroundings.

30 Which equation has a negative value of enthalpy change?

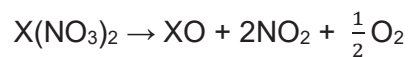
- A  $\text{CO}_2\text{(s)} \rightarrow \text{CO}_2\text{(g)}$
- B  $\text{Cl(g)} + \text{e}^- \rightarrow \text{Cl}^-\text{(g)}$
- C  $\text{Cl}_2\text{(g)} \rightarrow 2\text{Cl(g)}$
- D  $\text{NH}_4\text{Cl(s)} \rightarrow \text{NH}_4\text{Cl(aq)}$

31 When  $50 \text{ cm}^3$  of  $1 \text{ mol/dm}^3 \text{ HCl}$  is mixed with  $50 \text{ cm}^3$  of  $1 \text{ mol/dm}^3 \text{ NaOH}$ , the temperature of the resulting solution increases by  $6 \text{ }^\circ\text{C}$ . What will be the temperature change when  $100 \text{ cm}^3$  of each of these solutions are mixed?

- A  $3 \text{ }^\circ\text{C}$
- B  $6 \text{ }^\circ\text{C}$
- C  $12 \text{ }^\circ\text{C}$
- D  $24 \text{ }^\circ\text{C}$



34 Group II nitrates undergo thermal decomposition according to the following equation.

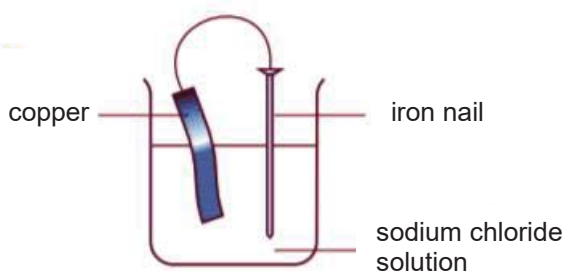


Which Group II nitrate requires the highest temperature to bring about its thermal decomposition?

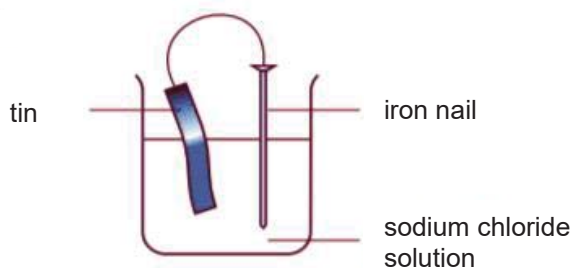
- A barium nitrate
- B calcium nitrate
- C magnesium nitrate
- D strontium nitrate

35 In which experiment would the iron nail **not** rust?

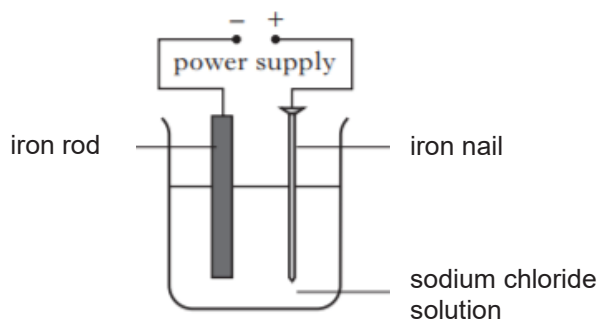
A



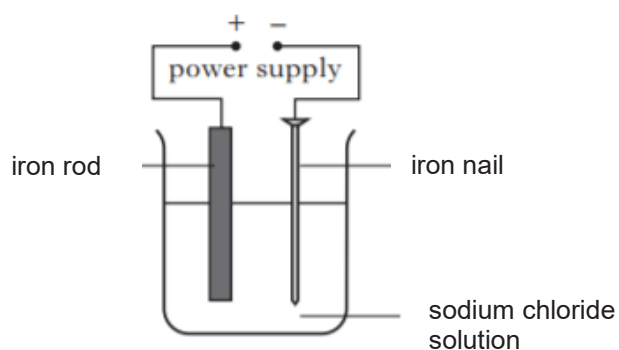
B



C



D



36 In which parts of a motor car do the reactions, shown in the equations, take place?

	$\text{N}_2 + \text{O}_2 \rightarrow 2\text{NO} + 2\text{CO}$	$2\text{CO} + 2\text{NO} \rightarrow 2\text{CO}_2 + \text{N}_2$
<b>A</b>	engine	engine
<b>B</b>	engine	exhaust
<b>C</b>	exhaust	engine
<b>D</b>	exhaust	exhaust

37 During the electrolysis of an aqueous solution of a molybdenum salt, 21 g of molybdenum is deposited at the cathode by 2 moles of electrons. What is the formula of the molybdenum ion? ( $A_r$  of Mo = 42)

- A**  $\text{Mo}^+$                       **B**  $\text{Mo}^-$                       **C**  $\text{Mo}^{2+}$                       **D**  $\text{Mo}^{4+}$

38 The same quantity of electricity is passed through separate dilute solutions of sulfuric acid and copper(II) sulfate using platinum electrodes under the same conditions.

Which statement is correct?

- A** The amount of copper deposited at the cathode in the copper(II) sulfate solution is half the amount of hydrogen gas formed at the cathode in the sulfuric acid solution.  
**B** The pH of both solutions increases as the electrolysis proceeds.  
**C** The same volume of hydrogen is obtained in both cases.  
**D** The same volume of oxygen is obtained in both cases.

39 A simple cell is made from magnesium and iron half-cells. Which statement is correct when the cell produces electricity?

- A** Electrons are lost from magnesium atoms.  
**B** Electrons flow from the iron half-cell to the magnesium half-cell.  
**C** Negative ions migrate to the iron half-cell.  
**D** The concentration of  $\text{Fe}^{2+}$  ions increases.

40 Electrolysis is used to plate a metal statue with silver. The statue is an electrode in a suitable electrolyte. Which row is correct?

	statue	electrolyte
<b>A</b>	anode	$\text{AgCl}(\text{s})$
<b>B</b>	anode	$\text{AgNO}_3(\text{aq})$
<b>C</b>	cathode	$\text{AgCl}(\text{s})$
<b>D</b>	cathode	$\text{AgNO}_3(\text{aq})$

# The Periodic Table of Elements

Group		I	II	III	IV	V	VI	VII	0
		1 H hydrogen 1							2 He helium 4
		<b>Key</b> proton (atomic) number atomic symbol name relative atomic mass							
3 Li lithium 7	4 Be beryllium 9			5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24			13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195
87 Fr francium -	88 Ra radium -	89 – 103 actinoids	104 Rf Rutherfordium -	105 Db dubnium -	106 Sg seaborgium -	107 Bh bohrium -	108 Hs hassium -	109 Mt meitnerium -	110 Ds darmstadtium -
							111 Rg roentgenium -	112 Cn copernicium -	113 Nh nihonium -
							114 Fl flerovium -	115 Mc moscovium -	116 Lv livermorium -
									117 Ts tennessine -
									118 Og oganeson -

lanthanoids

57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium -	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
89 Ac actinium -	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium -	94 Pu plutonium -	95 Am americium -	96 Cm curium -	97 Bk berkelium -	98 Cf californium -	99 Es einsteinium -	100 Fm fermium -	101 Md mendelevium -	102 No nobelium -	103 Lr lawrencium -

actinoids

The volume of one mole of any gas is  $24 \text{ dm}^3$  at room temperature and pressure (r.t.p.).



## Section A

Answer **all** questions in this section in the spaces provided.

The total mark for this section is 50.

**A1** The table shows some physical properties of four substances.

substance	melting point / °C	boiling point / °C	electrical conductivity	
			when solid	when molten
<b>A</b>	119	445	poor	poor
<b>B</b>	839	1484	good	good
<b>C</b>	1710	2230	poor	poor
<b>D</b>	501	950	poor	good

(a) Match **A** to **D** to the following substances:

lead, lead(II) chloride, silicon dioxide, sulfur

**A:** .....

**B:** .....

**C:** .....

**D:** .....

[4]

(b) Lead forms another chloride compound, lead(IV) chloride. The melting point and boiling point of this chloride is  $-15\text{ }^{\circ}\text{C}$  and  $50\text{ }^{\circ}\text{C}$  respectively.

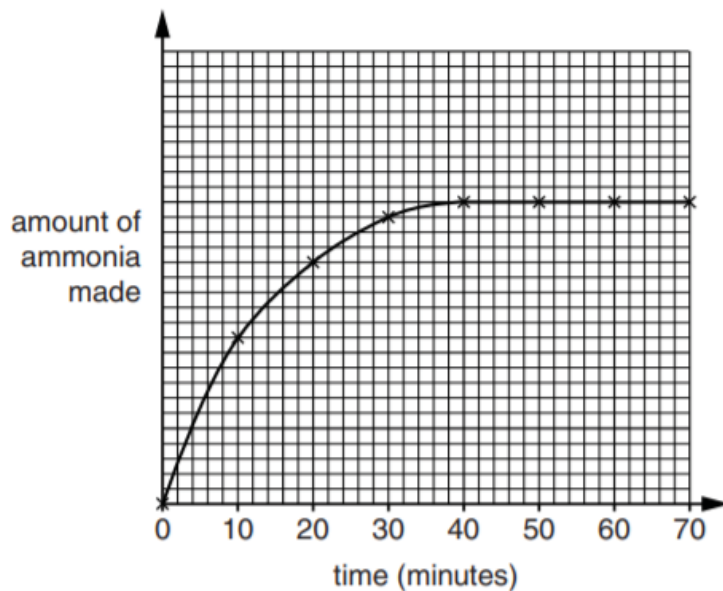
Draw the 'dot-and-cross' diagram to show the bonding in lead(IV) chloride. You need to draw the outer shell electrons only.

[1]

[Total: 5]

**A2** In the Haber Process, nitrogen and hydrogen react to make ammonia,  $\text{NH}_3$ .

A chemist heats some nitrogen and hydrogen with a catalyst in a closed container. She plots a graph to show how the amount of ammonia made changes with time.



(a) State the time that the amount of ammonia made stops increasing.

.....[1]

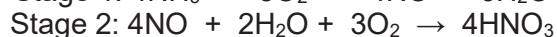
(b) The amount of ammonia made stops increasing when the reaction reaches equilibrium. At equilibrium, reaction is still going on. Explain why the amount of ammonia made is not increasing even though the reaction is still going on.

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

(c) Give **two** reasons to explain how the use of a catalyst reduces the cost of making ammonia.

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

(d) Ammonia is used to manufacture nitric acid by a two-stage process.



Use the two equations to construct an overall equation for the conversion of ammonia to nitric acid.

.....[1]

[Total: 6]

**A3** Both natural gas and charcoal are commonly used as fuels. Natural gas consists of mainly methane and is formed when layers of decomposing plant and animal matter are exposed to intense heat and pressure under the surface of the Earth over millions of years.

Charcoal consists of mainly carbon. It has been produced for many centuries by heating wood in the absence of oxygen.

(a) The values of some average bond enthalpies are shown in the table below.

bond	bond energy (kJ/mol)
C – C	348
C = O	799
O = O	495
O – O	142
O – H	463

Given the standard enthalpy change of combustion of methane is  $-889$  kJ/mol, calculate the bond energy of a C – H bond.

[3]

(b) The enthalpy changes of combustion of charcoal (carbon) and methane are in the table below.

substance	enthalpy changes of combustion kJ/mol
charcoal (carbon)	-394
methane	-889

Two students were discussing the use of charcoal and methane as fuels.

Student 1: 'Methane produces more heat per gram when burned so it is a better fuel.'

Student 2: 'The use of charcoal contributes less to the overall increase of carbon dioxide levels in the atmosphere.'

(i) Show that student 1 is correct in stating that methane produces more heat per gram.

[1]

(ii) With the help of chemical equations, show if charcoal produces less carbon dioxide compared to methane.

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

(iii) Hence, explain how student 2 comes to his conclusion.

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

[Total: 8]

**A4** Cerium is a lanthanoid metal that shows similar chemical reactions to some elements in the third period. Most of cerium's compounds contain  $\text{Ce}^{3+}$  or  $\text{Ce}^{4+}$  ions.

**(a)** Cerium reacts slowly with cold water and quickly with hot water forming cerium(III) hydroxide and hydrogen gas.

Place the order of reactivity of cerium among the Period 3 metals, starting with the most reactive metal.

.....[1]

**(b)** Cerium tarnishes slowly in air forming cerium(IV) oxide.

**(i)** State the formula of cerium(IV) oxide.

.....[1]

**(ii)** Cerium(IV) oxide reacts with aqueous sodium hydroxide to form a salt called sodium cerate,  $\text{Na}_2\text{CeO}_3$ .

State what type of oxide cerium(IV) oxide is.

.....[1]

**(iii)** Cerium(IV) oxide is a ceramic. Suggest **two** physical properties of cerium(IV) oxide.

1.....

2.....[2]

**(c)** Suggest if cerium compounds are suitable to be used as catalysts. Explain your reasoning.

.....

.....[1]

**(d)** Cerium is a better electrical conductor than sodium. Explain why.

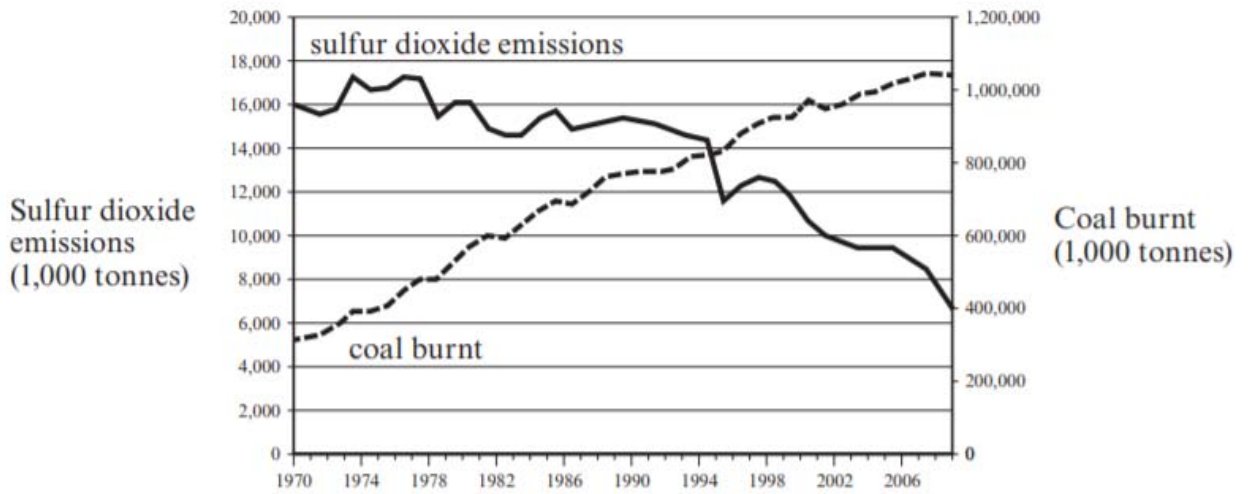
.....

.....

.....[1]



(b) The following graph shows the amount of coal burnt and sulfur dioxide emissions in the USA between 1970 and 2008.



(i) Describe the trends shown in the graph.

.....  
 .....[1]

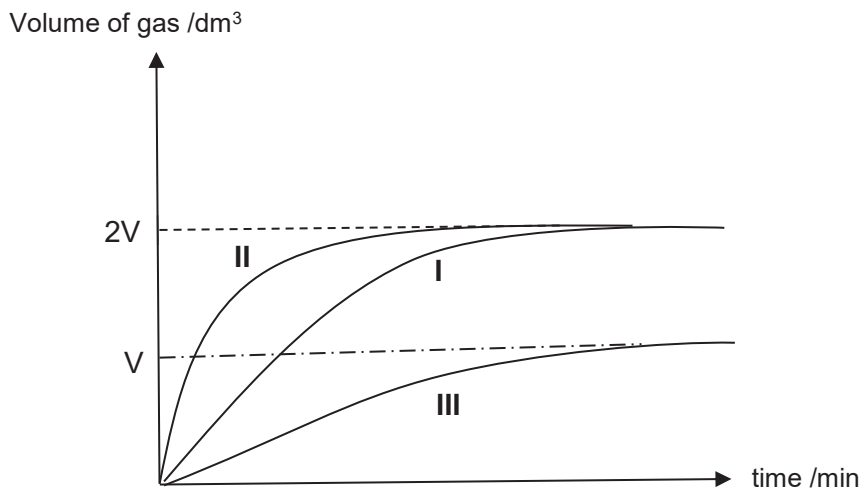
(ii) Suggest and explain how a possible measure put in place leads to the trend in sulfur dioxide emissions.

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

[Total: 5]

**A6** An experiment is carried out to investigate the rate of reaction of zinc with hydrochloric acid. Excess zinc powder, 3.00 g, is added to 50 cm<sup>3</sup> of 1.0 mol/dm<sup>3</sup> hydrochloric acid. The volume of gas produced is collected at regular intervals.

The experiment was repeated to study the factors affecting the rate of reaction. The diagram below shows the results of the experiments, with Graph I obtained from using 50 cm<sup>3</sup> of 1.0 mol/dm<sup>3</sup> hydrochloric acid.



(a) Identify the conditions used to obtain Graphs II and III.

Graph II: .....

Graph III: ..... [1]

(b) Explain, in terms of collisions between the particles, how using zinc powder instead of a piece of zinc metal affects the rate of reaction.

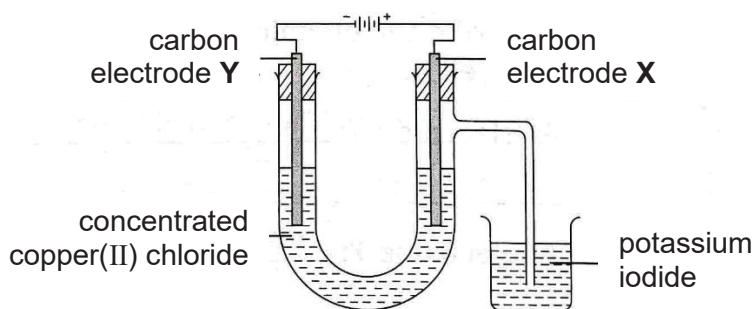
.....  
 .....  
 .....  
 ..... [2]

(c) Sketch on the diagram above, the graph that would be obtained if the experiment was repeated using 50 cm<sup>3</sup> of 1.0 mol/dm<sup>3</sup> ethanoic acid. Label your graph as IV. [1]

Explain your reasoning.  
 .....  
 .....  
 .....  
 .....  
 ..... [2]



**A7** An experiment on electrolysis was carried out using the apparatus as shown below.



**(a)** Describe what was observed at electrodes **X** and **Y**.

Electrode **X**: .....[1]

Electrode **Y**: .....[1]

**(b)** What was the colour change in the electrolyte after electrolysis had been carried out for some time? Explain your reasoning.

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

**(c)** Explain whether there would be any difference in the colour change of the electrolyte if the anode was replaced by copper electrode.

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

**(d)** Describe what colour change would be observed in the beaker containing aqueous potassium iodide after some time.

.....[1]

[Total: 7]

**Section B**

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

**B8 Hard water and soft water**

Hard water is water that has high mineral content, made up of largely calcium and magnesium ions in water. The metal ions make the water hard. The hardness of water causes a build-up of lime-scale in kettles, boilers and water pipes. This lime-scale on the heating element of kettles make it inefficient as the scale acts as an insulator.

Soft water contains low concentration of calcium and magnesium ions and therefore does not cause a build-up of lime-scale. However, drinking soft water will not provide the essential minerals for bone growth.

**Types of water hardness**

Temporary hardness in water is due to the presence of thermally unstable magnesium hydrogen carbonate or calcium hydrogen carbonate dissolved in the water. These minerals come from geological formations like limestone.

Permanent hardness in water is due to the presence of dissolved sulfates, hydrogen carbonates or chlorides of calcium and magnesium.

**Methods of softening water**

The temporary hardness in water can be removed by boiling.

On the other hand, permanent hard water cannot be softened by boiling. In order to soften water, the metal ions that cause hardness must be removed. One way to do this is to add sodium carbonate into the water to precipitate out the calcium or magnesium ions.

**The soap test**

Hard water does not lather easily.

Soft water lathers readily, and therefore requires less soap for the same cleaning effort.

Tim investigates the hardness of different water samples. He uses distilled water and two other water samples labelled **A** and **B**.

He adds soap solution to 100 cm<sup>3</sup> of each sample until a lasting lather is formed.

Tim next boils fresh 100 cm<sup>3</sup> samples of distilled water, sample **A** and sample **B**. He repeats the test with soap solution on the boiled samples.



(d) Suggest another method that can remove permanent and temporary hardness in water.

.....[1]

(e) Hardness of water can be a disadvantage as it causes a build-up of limescale in water pipes. However, there is an advantage of this limescale in water pipes. Suggest what this advantage is.

.....  
 .....  
 .....[1]

(f) Explain why water treated with sodium carbonate to remove permanent hardness may not be suitable for crops that grow well in slightly acidic soils.

.....  
 .....  
 .....[1]

[Total: 12]

**B9** The table below shows the percentage abundance and date of discovery for different metals in the Earth's crust.

metal	percentage by mass in Earth's crust	date of discovery (b.p = years before present)
aluminium	8.1	1825
iron	5.0	about 4000 b.p
calcium	3.6	1808
potassium	2.6	1807
magnesium	2.1	1775
zinc	0.11	1500
copper	0.01	about 5000 b.p
silver	0.00003	about 5000 b.p
gold	less than 0.000001	at least 8000 b.p

(a) The price of three metals are given below.

Aluminium = US\$ 0.00148 / g  
 Zinc = US\$ 0.00192 / g  
 Gold = US\$ 54.4 / g

Explain why gold is much more expensive than aluminium or zinc.

.....  
 .....[1]

**(b)** Use information from the table to explain whether the more abundant metals in the Earth's crust were discovered first.

.....  
.....  
.....  
.....  
.....  
.....  
.....[3]

**(c)** Suggest when sodium was discovered.  
.....[1]

**(d)** Explain the relationship between the reactivity of the metals and their date of discovery.  
.....  
.....  
.....[2]

**(e)** Suggest why aluminium was discovered later than potassium or calcium.  
.....  
.....  
.....[1]

[Total: 8]

**Either**

**B10** Magnesium is a valuable, light-weight metal, used as a structural material as well as in alloys, in batteries and in synthesis of other chemical products.

Magnesium forms the second most abundant cation in the sea, and it is cheaper to 'mine' magnesium from sea water than earth crust.

In the first stage of the extraction of magnesium, calcium carbonate is heated at high temperatures to produce quicklime or calcium oxide. When calcium oxide is treated with seawater, it forms calcium hydroxide, which is slightly soluble and ionises to give calcium and hydroxide ions. The hydroxide ions formed would then cause the precipitation of magnesium ions from seawater.

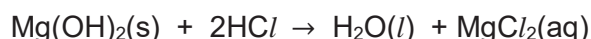
(a) Write an ionic equation for the reaction of calcium oxide with seawater.

.....[2]

(b) Suggest why magnesium hydroxide is precipitated instead of calcium hydroxide.

.....[1]

(c) The precipitate is filtered and reacted with hydrochloric acid to form magnesium chloride solution.



Briefly describe how solid magnesium chloride can be obtained from the mixture.

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

(d) In the second stage of the extraction of magnesium, some sodium chloride and calcium chloride are added to the solid magnesium chloride and the mixture is melted in an electrolytic cell. The mixture of sodium chloride and calcium chloride lowers the melting point of magnesium chloride.

Suggest why zinc chloride **cannot** be added into the electrolytic cell to lower the melting point.

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

(e) Write the half equations for the reactions happening at the anode and cathode.

Anode: .....

Cathode: .....[2]

- (f) Chlorine gas, a by-product of this reaction is dissolved in water to produce hydrochloric acid.



A student claims that chlorine is only oxidised in this reaction. Explain if you agree with this claim.

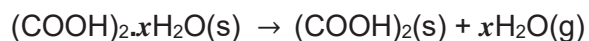
.....  
.....[1]

[Total: 10]

Or

- B10** Ethanedioic acid (oxalic acid) has the formula  $(\text{COOH})_2$ . It can be made in the laboratory by oxidising sugar with a powerful oxidising agent.

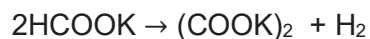
After purification, the oxalic acid is produced as white crystals of a hydrate,  $(\text{COOH})_2 \cdot x\text{H}_2\text{O}$ . On heating this hydrate, water is lost, leaving anhydrous oxalic acid.



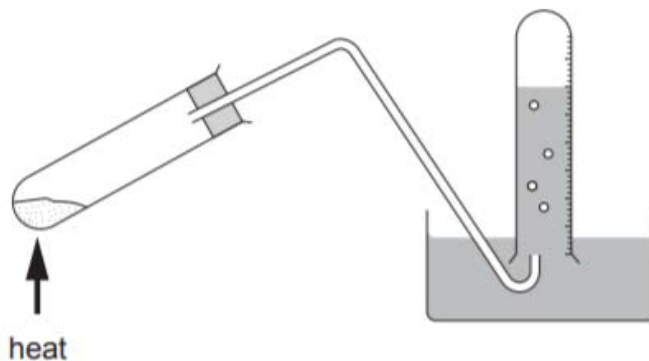
- (a) In an experiment 5.67 g of the hydrate were heated to constant mass, giving 4.05 g of the anhydrous acid. Calculate the value of  $x$  in  $(\text{COOH})_2 \cdot x\text{H}_2\text{O}$ .

[3]

- (b) Another method of producing oxalic acid in the laboratory is to heat potassium methanoate, HCOOK. This produces potassium oxalate, which is then acidified to give the acid.



Some students carried out this experiment using the apparatus below. They collected the hydrogen gas produced over water.



A few students obtained a smaller volume of hydrogen than expected. Suggest **two** practical reasons why this may have occurred, apart from leaks.

1.....[1]

.....[1]

2.....[1]

.....[1]

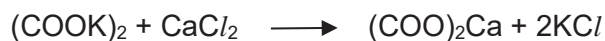
(c) Bob was asked to analyse a mixture of potassium methanoate and potassium oxalate. He weighed out 4.69 g of the mixture and carried out the separation technique below.

- The mixture was completely dissolved in distilled water.
- Calcium chloride solution was added to this solution to precipitate out calcium oxalate.
- The mixture was then filtered and the precipitated calcium oxalate was washed and dried.

(i) Suggest how Bob would know whether sufficient calcium chloride solution had been added to react with all of the potassium oxalate present.

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

(ii) In his experiment, Bob obtained 2.49 g of pure and dry calcium oxalate.



Calculate the percentage of potassium oxalate in the mixture.

[M<sub>r</sub> : (COOK)<sub>2</sub>, 166; (COO)<sub>2</sub>Ca, 128]

[3]

[Total: 10]

End of paper

# The Periodic Table of Elements

		Group																																																																															
I	II	III	IV	V	VI	VII	0																																																																										
3 Li lithium 7	4 Be beryllium 9	11 Na sodium 23	12 Mg magnesium 24	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40	19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84	37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131	55 Cs caesium 133	56 Ba barium 137	57-71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium -	85 At astatine -	86 Rn radon -	87 Fr francium -	88 Ra radium -	89-103 actinoids	104 Rf Rutherfordium -	105 Db dubnium -	106 Sg seaborgium -	107 Bh bohrium -	108 Hs hassium -	109 Mt meitnerium -	110 Ds darmstadtium -	111 Rg roentgenium -	112 Cn copernicium -	113 Nh nihonium -	114 Fl flerovium -	115 Lv livermorium -	116 Og oganeson -	117 Ts tennessine -	118 Uue unbinilium -

## Key

proton (atomic) number  
atomic symbol  
name  
relative atomic mass

1  
H  
hydrogen  
1

lanthanoids

57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium -	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
89 Ac actinium -	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium -	94 Pu plutonium -	95 Am americium -	96 Cm curium -	97 Bk berkelium -	98 Cf californium -	99 Es einsteinium -	100 Fm fermium -	101 Md mendelevium -	102 No nobelium -	103 Lr lawrencium -

actinoids

The volume of one mole of any gas is  $24 \text{ dm}^3$  at room temperature and pressure (r.t.p.).

