Paper 1 Chemistry
6 Mark Questions
(Higher Triple)

N.B: The level of each question has been given to show you the difficulty. The level 3 questions will require you to think outside the box and use your knowledge in possibly unseen circumstances. Generally speaking, level 2 questions make up the first half of the paper and level 3 questions make up the second half of the paper.

Index:

C1 & 2 Atomic Structure and the Periodic Table

Q1. Level 2

In the 1860s scientists were trying to organise elements.

Figure 2 shows the table published by John Newlands in 1865.
The elements are arranged in order of their atomic weights.

Figure 2

H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cr	Ti	Mn	Fe
Co,Ni	Cu	Zn	Y	In	As	Se
Br	Rb	Sr	Ce,La	Zr	Di,Mo	Ro,Ru
Pd	Ag	Cd	U	Sn	Sb	Te

Figure 3 shows the periodic table published by Dmitri Mendeleev in 1869.

Figure 3

H							
Li	Be	B	C	N	O	F	
Na	Mg	Al	Si	P	S	Cl	
K Cu	Ca Zn	? ?	Ti ?	V As	Cr Se	Mn Br	Fe Co Ni
Rb Ag	Sr Cd	Y In	Zr Sn	Nb Sb	Mo Te	? I	Ru Rh Pd

Mendeleev's table became accepted by other scientists whereas Newlands' table was not.

Evaluate Newlands' and Mendeleev's tables.

You should include:

- a comparison of the tables
- reasons why Mendeleev's table was more acceptable.

Use **Figure 2** and **Figure 3** and your own knowledge.

(6)

Top tips for planning:

Evaluate - Students should use the information supplied, as well as their knowledge and understanding, to consider evidence for and against when making a judgement.

Students often overlook the similarities between the two models e.g. they are ordered by atomic weight. Students usually refer to the fact that spaces are left but then don't refer back to the fact that new elements were discovered which fit those gaps. From the two bullet points given above, these ideas must be incorporated to help formulate your answers, along with your own knowledge of how Mendeleev arranged

Sample Student Answer

FROM THE FIGURES ABOVE, IT IS SEEN THAT BOTH SCIENTISTS ORDERED THE ELEMENTS BY INCREASING ATOMIC WEIGHT AND THAT THERE ARE SOME SIMILARITIES IN GROUPING THE ELEMENTS E.G. SOME OF THE HALOGENS. IT IS ALSO SHOWN IN SOME INSTANCES THAT THERE IS MORE THAN ONE ELEMENT IN EACH BOX.

THE REASON WHY MENDELEEV'S MODEL WAS MORE WIDELY ACCEPTED IS BECAUSE HE CHANGED SOME OF THE ORDERS OF ELEMENTS TO FIT THE CHEMICAL REACTIVITY RATHER THAN MASS E.G. TELLIRIUM AND IODINE. HE ALSO LEFT GAPS FOR UNDISCOVERED ELEMENTS WHICH WERE LATER FILLED BY NEW ELEMENTS WHICH FIT THE EXPECTED PROPERTIES.

the elements.

Q2. Level 3

The plum pudding model of the atom was replaced by the nuclear model.

The nuclear model was developed after the alpha particle scattering experiment.

Compare the plum pudding model with the nuclear model of the atom.

(4)

Top tips for planning:

Compare - describe the similarities and/or differences between things, not just write about one.

Begin by talking about the plum pudding model and then state how the nuclear model is different e.g. where the electrons are in each model.

Sample Student Answer

THE PLUM PUDDING MODEL SUGGESTS THAT THE ATOM IS A BALL OF POSITIVE CHARGE WITH ELECTRONS SPREAD WITHIN IT, WHEREAS THE NUCLEAR MODEL HAS A POSITIVE CHARGE AT THE CENTRE ON THE ATOM AND THE ELECTRONS ORBIT AROUND THE OUTSIDE. THE PLUM PUDDING MODELS MASS IS SPREAD THROUGHOUT THE ATOM WHERES THE NUCLEAR MODEL PUTS THE MASS IN THE CENTRE OF THE ATOM (NUCLEUS). THERE IS EMPTY SPACE BETWEEN THE CENTRE OF THE ATOM AND THE OUTER ELECTRONS IN THE NUCLEAR MODEL, HOWEVER THE PLUM PUDDING MODEL DOESN’T HAVE AREAS OF EMPTY SPACE.

C3 Structure and Bonding

Q3. Level 2

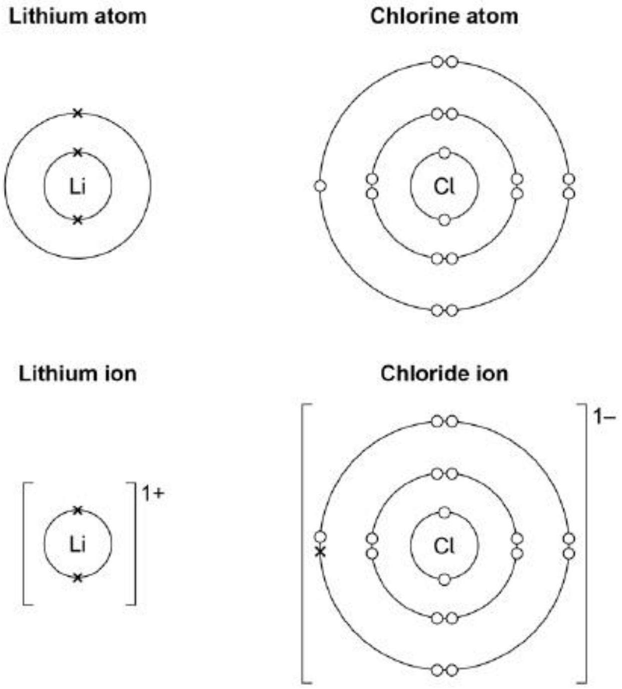
This question is about metal compounds.

Lithium reacts with chlorine to produce lithium chloride.

When lithium atoms and chlorine atoms react to produce lithium chloride, lithium ions and chloride ions are formed.

The diagram shows the electronic structures of the atoms and ions.

The symbols **o** and **x** are used to represent electrons.



Describe what happens when a lithium atom reacts with a chlorine atom.

Answer in terms of electrons.

(4)

Top tips for planning:

Describe - recall process of events

Identify which group each element is from to understand how many outer electrons is has started with, then think about how many it needs to gain or lose to become a full shell. Describe the movement of electrons as a 'transfer' and give the specific number of electrons being transferred to gain maximum marks.

Sample Student Answer

THE LITHIUM ATOM LOSES 1 ELECTRON WHICH IS TRANSFERRED TO CHLORINE TO FORM A POSITIVE ION WITH A +1 CHARGE. THE CHLORINE ATOM GAINS THIS ONE ELECTRON AND BECOMES A NEGATIVELY CHARGED ION WITH A -1 CHARGE.

Q4. Level 3

This question is about structure and bonding.

Graphite and fullerenes are forms of carbon.

Graphite is soft and is a good conductor of electricity.

Explain why graphite has these properties.

Answer in terms of structure and bonding.

(4)

Top tips for planning:

Explain - give reasons for something happening

First identify what graphite is made of and then think about where it is on the periodic table. What type of bonding will it have? Think about the number of joining bonds and the forces that act on this type of bond. What is significant about it's structure which allows it to be 'soft' and a good conductor?

Sample Student Answer

GRAPHITE IS MADE FROM CARBON ATOMS WHICH ARE BONDED TOGETHER BY COVALENT BONDS. EACH CARBON FORMS COVALENT BONDS TO 3 OTHER CARBON ATOMS AND IS ARRANGED IN HEXAGONAL LAYERS HELD TOGETHER BY WEAK INTERMOLECULAR FORCES. THIS ALLOWS THE LAYERS TO SLIDE OVER EACH OTHER. THE DELOCALISED ELECTRON CAN THEN CARRY THE CURRENT.

C4 Quantitative Chemistry

Q5. Level 3

The overall equation for the electrolysis of aluminium oxide is:

$$2\ Al_2O_3 \rightarrow 4\ Al + 3\ O_2$$

Calculate the mass of oxygen produced when 2000 kg of aluminium oxide is completely electrolysed.

Relative atomic masses (A_r): O = 16 Al = 27

(4)

Top tips for planning:

Follow the following steps to determine the mass produced:

1. **Identify the calculation triangle you need to use**
2. **Find the relative formula mass of Al_2O_3**
3. **Use the equation to find the number of moles of Al_2O_3 remember to convert into g rather than kg so x1000**
4. **Find the number of moles of O_2 using the mole ratio**
5. **Rearrange the equation to find the mass of O_2 convert to kg by dividing by 1000.**

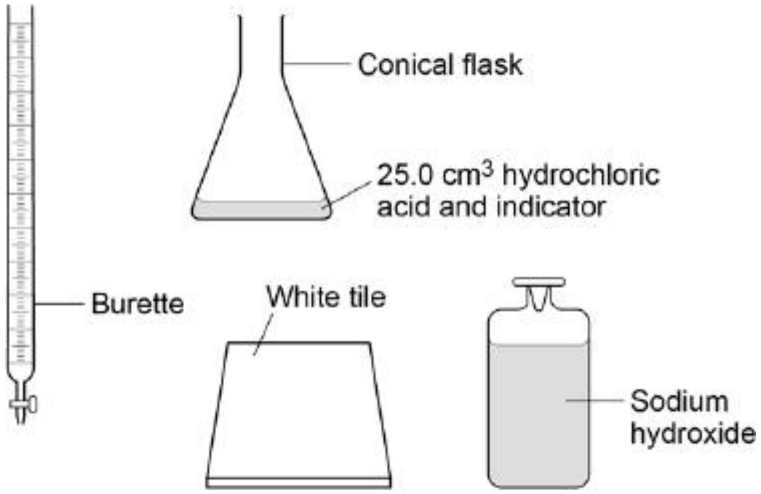
Sample Student Answer

1. MOLES = MASS/RELATIVE FORMULA MASS
2. RELATIVE FORMULA MASS OF ALUMINIUM OXIDE = 102
3. MOLES OF ALUMINIUM OXIDE = 2 000 000 / 102 = 19 608
4. RATIO IS 2:3 SO 19 608 X 3/2 = 29 412 MOLES OF OXYGEN
5. MASS OF OXYGEN = MOL X VOL = (29 412 X 32)/1000 = 941 KG

Q6. Level 2

Sodium hydroxide reacts with hydrochloric acid.

The diagram shows apparatus that can be used to find the volume of sodium hydroxide reacting with 25.0 cm^3 hydrochloric acid.



Describe a method to find the exact volume of sodium hydroxide that reacts with 25.0 cm^3 of hydrochloric acid.

(6)

Top tips for planning:

Describe - recall process of events

In this case you have been given an image to assist in your answer. Think about the significance of each piece of equipment e.g. what would you need to say about the white tile? Where would you put the sodium hydroxide?

Sample Student Answer

FILL THE BURETTE WITH SODIUM HYDROXIDE. PUT THE CONICAL FLASK UNDER THE BURETTE ON TOP OF THE WHITE TILE. ADD THE SODIUM HYDROXIDE TO THE CONICAL FLASK WHILST SWIRLING. CHANGE THE RATE OF ADDITION TO DROPWISE AS YOU NEAR THE END-POINT OF THE REACTION. THIS IS WHEN YOU WILL SEE THE COLOUR CHANGE IN THE SOLUTION. MEASURE THE VOLUME OF SODIUM HYDROXIDE ADDED TO THE CONICAL FLASK AND RECORD THIS. REPEAT THE EXPERIMENT AGAIN TO GAIN AN AVERAGE OF YOUR RESULTS.

Q7. Level 3

A student investigated the temperature change in the reaction between dilute sulfuric acid and potassium hydroxide solution.

This is the method used.

1. Measure 25.0 cm^3 potassium hydroxide solution into a polystyrene cup.
2. Record the temperature of the solution.
3. Add 2.0 cm^3 dilute sulfuric acid.
4. Stir the solution.
5. Record the temperature of the solution.
6. Repeat steps 3 to 5 until a total of 20.0 cm^3 dilute sulfuric acid has been added.

The student repeated the investigation.

The student used solutions that had different concentrations from the first investigation.

The student found that 15.5 cm^3 of 0.500 mol/dm^3 dilute sulfuric acid completely reacted with 25.0 cm^3 of potassium hydroxide solution.

The equation for the reaction is:

$$2\ KOH + H_2SO_4 \rightarrow K_2SO_4 + 2\ H_2O$$

Calculate the concentration of the potassium hydroxide solution in mol/dm^3 and in g/dm^3

Relative atomic masses (A_r): H = 1   O = 16   K = 39

(6)

Top tips for planning:

Follow the following steps to determine the unknown concentration:

1. **Identify the calculation triangle you need to use**
2. **Use the equation to find the number of moles of dilute sulfuric acid using the given volume and concentration (remember to convert the cm^3 into dm^3 by dividing by 1000)**
3. **Find the number of moles of potassium hydroxide by using the mole ratio**
4. **Rearrange the equation to find the concentration of potassium hydroxide using the given volume and number of moles you have just worked out**
5. **To find the concentration in g/dm^3, first work out the relative formula mass of potassium hydroxide and then multiply your answer for step 4 above by the relative formula mass**

Sample Student Answer

1. MOLES = VOLUME X CONCENTRATION
2. MOLES OF H_2SO_4 = (15/1000) X 0.500 = 0.00775 MOL
3. RATIO IS 2:1 SO DOUBLE THE NUMBER OF MOLES = 0.0155 MOL OF KOH
4. CONCENTRATION = MOL/VOL = 0.0155/(25/1000) = 0.62 MOL/DM^3
5. M_R OF KOH = 56 SO 56 X 0.62 = 34.7 G/DM^3

Q8. Level 3

Propane burns to form carbon dioxide and water.

The equation for the reaction is:

$$C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(l)$$

3.60 dm^3 carbon dioxide is produced when a sample of propane is burned in 7.25 dm^3 oxygen.

Calculate the volume of unreacted oxygen.

Give your answer in cm^3

(4)

Top tips for planning:

Follow the following steps to determine the volume of unreacted oxygen:

1. **Find the ratio of oxygen to carbon dioxide**
2. **Find the volume of oxygen needed to fully react with carbon dioxide using the volume of carbon dioxide given**
3. **Take away the amount of oxygen needed from the starting volume given in the question**
4. **Convert your answer into cm^3 by multiplying by 1000.**

Sample Student Answer

1. RATIO OF O_2 TO CO_2 = 5:3
2. OXYGEN NEEDED = (3.60 X 5/3) = 6.0 DM^3
3. OXYGEN UNREACTED = 7.25 – 6.0 = 1.25 DM^3
4. CONVERSION = 1.25 X 1000 = 1250 CM^3 OF UNREACTED OXYGEN

Q9. Level 2

Soluble salts are formed by reacting metal oxides with acids.

Describe a method to make pure, dry crystals of magnesium sulfate from a metal oxide and a dilute acid.

(6)

Top tips for planning:

Describe - recall process of events

- *What chemicals will you react together to make magnesium sulfate? What must the metal oxide be? Which acid would you use to make a sulfate?*
- *Write bullet points like you would a method – made up of key points from the practical*
- *What key things happen in the practical which will affect the outcome of the experiment e.g. does it matter if you don't complete the filtration*
- *Write in a logical order e.g. would you be able to filter the product in the final step or would this need to come before?*

Sample Student Answer

ADD MAGNESIUM OXIDE TO WARM SULFURIC ACID IN A BEAKER. STIR THE CONTENTS AND KEEP ADDING MAGNESIUM OXIDE UNTIL NO FURTHER REACTION IS OBSERVED. FILTER THE EXCESS UNREACTED MAGNESIUM OXIDE USING FILTER PAPER AND A FUNNEL. HEAT THE REMAINING SOLUTION IN AN EVAPORATING DISH TO REDUCE THE VOLUME BY HALF. PUT THE SATURATED SOLUTION INTO A PETRI DISH AND LEAVE TO CRYSTALLISE. PAT DRY WITH FILTER PAPER IF NEEDED.

Q10. Level 3

A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

The table below shows the student's results.

Metal	**Temperature increase in °C**
Copper	0
Iron	13
Magnesium	43
Zinc	17

The temperature change depends on the reactivity of the metal.

The student's results are used to place copper, iron, magnesium and zinc in order of their reactivity.

Describe a method to find the position of an unknown metal in this reactivity series.

Your method should give valid results.

(4)

Top tips for planning:

Describe - recall process of events

This question has given you a rough method already to help answer the question. You should be thinking about how you would complete the same experiment and how the results would help you determine where the metal fits in the reactivity series compared to the above results.

Sample Student Answer

ADD THE UNKNOWN METAL TO A COPPER SULPHATE SOLUTION. RECORD THE TEMPERATURE CHANGE FROM BEGINNING TO END OF THE REACTION. WORK OUT THE OVERALL TEMPERATURE CHANGE. REPEAT THIS WITH THE OTHER METALS, KEEPING THE VOLUME OF SOLUTION AND CONCENTRATION OF SOLUTION THE SAME. PLACE THE METALS IN ORDER OF THEIR OVERALL TEMPERATURE CHANGE TO DETERMINE THE ORDER OF REACTIVITY.

Q11. Level 2

Chemical reactions can produce electricity.

The table below shows data about different ways to power electric cars.

	Hydrogen fuel cell	**Rechargeable lithium-ion battery**
Time taken to refuel or recharge in minutes	5	30
Distance travelled before refuelling or recharging in miles	Up to 415	Up to 240
Distance travelled per unit of energy in km	22	66
Cost of refuelling or recharging in £	50	3
Minimum cost of car in £	60 000	18 000

Evaluate the use of hydrogen fuel cells compared with rechargeable lithium-ion batteries to power electric cars.

Use the table above and your own knowledge.

(6)

Top tips for planning:

Evaluate - Students should use the information supplied, as well as their knowledge and understanding, to consider evidence for and against when making a judgement.

Recall your own knowledge about the differences between a battery and a hydrogen fuel cell to help support your evaluation. You may want to make small bullet points to help remind yourself of key information you should mention which supports your judgement. All your arguments should be centred around supporting your overall judgement. There is no right or wrong answer in terms of which option you chose.

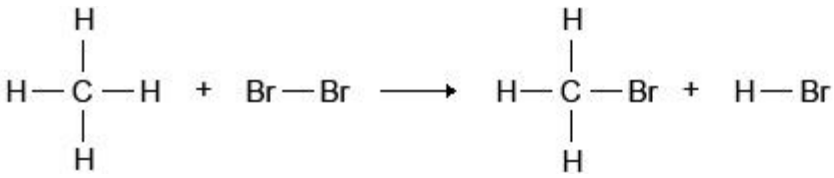
Sample Student Answer

USING THE INFORMATION ABOVE IT IS CLEAR THAT THE LITHIUM-ION CAR COSTS MUCH LESS THAN THE FUEL CELL ALTERNATIVE. IT ALSO REQUIRES LESS MONEY TO RECHARGE ALTHOUGH IT TAKES LONGER TO RECHARGE (25 MINS MORE). ALTHOUGH THE RANGE ISN'T AS GOOD, THE DISTANCE TRAVELLED PER UNIT OF ENERGY IS MUCH BETTER MAKING IT MUCH MORE EFFICIENT. THERE ARE MORE CHARGING POINTS AROUND FOR ELECTRIC CARS RATHER THAN HYDROGEN FUELLED CARS AND HYDROGEN IS FLAMMABLE MAKING THE STORAGE OF IT MORE DIFFICULT. ALSO, THERE ARE NO EMISSIONS PRODUCED. IN CONCLUSION, THE LITHIUM-ION BATTERY IS CURRENTLY THE BETTER OF THE TWO CARS.

Q12. Level 3

Bromine reacts with methane in sunlight.

The diagram below shows the displayed formulae for the reaction of bromine with methane.



The table below shows the bond energies and the overall energy change in the reaction.

	C—H	**Br—Br**	**C—Br**	**H—Br**	**Overall energy change**
Energy in kJ/mol	412	193	**X**	366	−51

Calculate the bond energy **X** for the C—Br bond.

Use the diagram and the table above.

(4)

Top tips for planning:

Follow the following steps to determine the overall bond energy:

1. **Total the sum of all the bond energies for the reactants (bonds broken)**
2. **Total the sum of all the bond energies of the products (bonds formed)**
3. **Input the values into the equation where overall bond enthalpy = bonds broken – bonds formed**
4. **Rearrange the equation to find the value of X**

Sample Student Answer

1. BONDS BROKEN = 4(C-H) + 1(BR-BR) = 4(412) + 193 = 1841
2. BONDS FORMED = 3(C-H) + H-BR + X = 3(412) + 366 = 1602 + X
3. -51 = 1841 – (1602 – X)
4. X = 1841 – 1602 + 51 = 290 KJ/MOL

Mark schemes

Q1.

Level 3 (5-6 marks):
A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.

Level 2 (3-4 marks):
Some logically linked reasons are given. There may also be a simple judgement.

Level 1 (1-2 marks):
Relevant points are made. They are not logically linked.

Level 0
No relevant content

Indicative content

comparative points
- both tables have more than one element in a box
- both have similar elements in the same column
- both are missing the noble gases
- both arranged elements in order of atomic weight

advantages of Mendeleev / disadvantages of Newlands
- Newlands did not leave gaps for undiscovered elements
- Newlands had many more dissimilar elements in a column
- Mendeleev left gaps for undiscovered elements
- Mendeleev changed the order of some elements (e.g. Te and I)

points which led to the acceptance of Mendeleev's table
- Mendeleev predicted properties of missing elements
- elements with properties predicted by Mendeleev were discovered
- Mendeleev's predictions turned out to be correct
- elements were discovered which fitted the gaps

6

Q2.

Level 2 (3-4 marks):
Scientifically relevant features are identified; the ways in which they are similar / different is made clear.

Level 1 (1-2 marks):
Relevant features are identified and differences noted.

Level 0
No relevant content.

Indicative content

similarities
- both have positive charges
- both have (negative) electrons
- neither has neutrons

differences

plum pudding model	**nuclear model**
ball of positive charge (spread throughout)	positive charge concentrated at the centre
electrons spread throughout (embedded in the ball of positive charge)	electrons outside the nucleus
no empty space in the atom	most of the atom is empty space
mass spread throughout	mass concentrated at the centre

4

Q3.

lithium (atom) loses (one) electron(s)

1

chlorine (atom) gains (one) electron(s)

1

reference to transfer of one electron

1

to form positive and negative ions

allow to form noble gas electronic structures
or
allow to form stable electron arrangements
or
allow to form full outer shells
or
allow reference to ionic bonding

1

Q4.

each (carbon) atom forms three covalent bonds

1

forming layers (of hexagonal rings)

1

(soft)
(because) layers can slide over each other

1

(conducts electricity)
(because of) delocalised electrons

1

Q5.

*an answer of 941 (kg) scores **4** marks*

(M_r of Al_2O_3 =) 102

$\left(\frac{2\,000\,000}{102} =\right)$ 19 608 (mol Al_2O_3)

allow correct calculation using incorrectly calculated value of M_r of Al_2O_3

1

$\left(19\,608 \times \frac{3}{2} =\right)$ 29 412 (mol O_2)

allow correct calculation using incorrectly calculated value of moles of Al_2O_3

1

$\left(\frac{29\,412 \times 32}{1000} =\right)$ 941 (kg)

allow 941.1764706 (kg) correctly rounded to at least 2 significant figures

allow correct answer using incorrectly calculated value of moles of O_2

1

alternative approach:

(2 M_r of Al_2O_3 =) 204 (1)

204 (kg of Al_2O_3) gives 96 (kg of O_2) (1)

(2000 kg of Al_2O_3 gives)

$\frac{2000}{204}$ x 96 (kg of O_2)

or

$\frac{2000000}{204}$ x 96 (g of O_2) (1)

= 941 (kg) (1)

Q6.

fill burette with sodium hydroxide

1

add sodium hydroxide from the burette to the hydrochloric acid and indicator

1

stop when colour changes

1

measure volume used from burette

1

plus any **two** from:

- stand flask on white tile
- swirl
- add dropwise near the endpoint
- repeat

2

Q7.

*an answer of 0.62 (mol/dm^3) for concentration in mol/dm^3 scores **4** marks*

*an answer of 0.31 (mol/dm^3) for concentration in mol/dm^3 scores **3** marks*

(moles H_2SO_4 = 0.500 × $\frac{15.5}{1000}$) = 0.00775

1

(moles KOH = 2 x moles H_2SO_4 = 2 x 0.00775) = 0.0155

allow correct calculation using incorrectly calculated value of moles of H_2SO_4

1

(conc KOH = moles KOH x $\frac{1000}{25.0}$) = 0.0155 x $\frac{1000}{25.0}$)

allow correct calculation using incorrectly calculated value of moles of KOH

1

= 0.62 (mol/dm^3)

allow correct answer using incorrectly calculated value of moles of KOH

1

(M_r KOH =) 56

1

(conc = M_r x conc in mol/dm^3 = 56 x 0.62) = 34.7 (g/dm^3)

allow 35 or 34.72 (g/dm^3)

allow correct answer using incorrectly calculated value of concentration in mol/dm^3 and/or incorrect M_r

1

alternative approach for step 1 to step 4

$\frac{2}{1} = \frac{25 \times \text{conc KOH}}{15.5 \times 0.500}$ (2)

(conc KOH) = $\frac{2 \times 15.5 \times 0.500}{25.0}$ (1)

= 0.62 (mol/dm^3) (1)

allow 1 mark if mole ratio is incorrect

1

Q8.

*an answer of 1250 (cm^3 oxygen unreacted) scores **4** marks*

ratio of O_2 : CO_2 = 5 : 3

1

(oxygen needed = $\frac{3.60 \times 5}{3}$)
= 6.0 (dm^3)

allow correct calculation using an incorrectly determined mole ratio

1

(oxygen unreacted = 7.25 − 6.0) = 1.25 (dm^3)

allow correct subtraction of an incorrectly calculated volume of oxygen

1

(oxygen unreacted = 1.25 × 1000)
= 1250 (cm^3)

allow correct conversion to cm^3 anywhere in response

1

alternative approach for MP1 and MP2

moles CO_2 = 0.15
and
moles O_2 = 0.25 (1)

(0.25 x 24 =) 6.0 (dm^3 oxygen needed) (1)

Q9.

Level 3: The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.

5−6

Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.

3−4

Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1−2

No relevant content

0

Indicative content

- use magnesium oxide and sulfuric acid
- add sulfuric acid to a beaker
- warm sulfuric acid
- add magnesium oxide
- stir
- continue adding until magnesium oxide is in excess

- filter
- using a filter paper and funnel
- to remove excess magnesium oxide

- heat solution in an evaporating basin
- to crystallisation point
- leave to crystallise
- pat dry with filter paper

credit may be given for diagrams

[6]

Q10.

suitable method described

1

the observations / measurements required to place in order

dependent on a suitable method

1

an indication of how results would be used to place the unknown metal in the reactivity series

1

a control variable to give a valid result

1

approaches that could be used

approach 1:
add the unknown metal to copper sulfate solution (1)

measure temperature change (1)

place the metals in order of temperature change (1)

any **one** from (1):
- same volume of solution
- same concentration of solution
- same mass / moles of metal
- same state of division of metal

approach 2:
add the metal to salt solutions of the other metals
or

heat the metal with oxides of the other metals (1)

measure temperature change (only if salt solutions used)
or
observe whether a chemical change occurs (1)

place the metals in order of temperature change **or**
compare whether there is a reaction to place in correct order (1)

any **one** from (1):
- same volume of salt solutions
- same concentration of salt solutions
- same (initial) temperature of salt solutions
- same mass / moles of metal **or** metal oxide
- same state of division of metal **or** metal oxide

approach 3:
add all of the metals to an acid (1)

measure temperature change or means of comparing rate of reaction (1)

place the metals in order of temperature change or rate of reaction (1)

any **one** from (1):
- same volume of acid
- same concentration of acid
- same (initial) temperature of acid
- same mass / moles of metal
- same state of division of metal

approach 4:
set up electrochemical cells with the unknown metal as one electrode and each of the other metals as the other electrode (1)

measure the voltage of the cell (1)

place the metals in order of voltage (1)

any **one** from (1):
- same electrolyte
- same concentration of electrolyte
- same (initial) temperature of acid
- same temperature of electrolyte

Q11.

Level 3: A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.

5−6

Level 2: Some logically linked reasons are given. There may also be a simple judgement.

3−4

Level 1: Relevant points are made. This is not logically linked.

1−2

No relevant content

0

Indicative content

reasons why fuel cells could be judged as better

from the table	**from other knowledge**
• time for refuelling a fuel cell is faster than recharging **or** a fuel cell does not need to be recharged • a fuel cell has a greater range	• hydrogen can be renewable if made by electrolysis using renewable energy • lithium-ion batteries can catch fire • produces only water **or** no pollutants produced • lithium-ion batteries may release toxic chemicals on disposal • lithium-ion batteries (eventually cannot be recharged so) have a finite life

reasons why the lithium-ion battery could be judged as better

from the table	**from other knowledge**
• lithium-ion uses energy more efficiently • cost of lithium-ion car much less • cost of recharging much less than refuelling with hydrogen	• hydrogen is often made from fossil fuels so is not renewable • charging points are more widely available than hydrogen filling stations • hydrogen takes up a lot of space **or** is difficult to store • hydrogen can be highly flammable / explosive • no emissions produced • (catalyst in the hydrogen fuel-cell eventually becomes poisoned so) have a finite life

[11]

Q12.

(bonds broken = 4(412) + 193 =)1841

1

(bonds formed = 3(412) + 366 + **X** =) 1602 + **X**

1

−51 = 1841 − (1602 + **X**)

allow use of incorrectly calculated values of bonds broken and / or bonds formed from steps 1 and 2 for steps 3 and 4

1

(**X** =) 290 (kJ/mol)

allow a correctly calculated answer from use of −51 = bonds formed − bonds broken

1

OR

alternative method ignoring the 3 unchanged C−H bonds

(412 + 193 =) 605 (1)

366 + **X** (1)

−51 = 605 − (366 + **X**) (1)

(**X** =) 290 (kJ/mol) (1)

*an answer of 290 (kJ/mol) scores **4** marks*

*an answer of 188 (kJ/mol) scores **3** marks*

*an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps*