10.2 Reactivity series

01. 0620_s20_qp_41 Q: 2
Magnesium is a metal.

(a) Name and describe the bonding in magnesium.

name .....

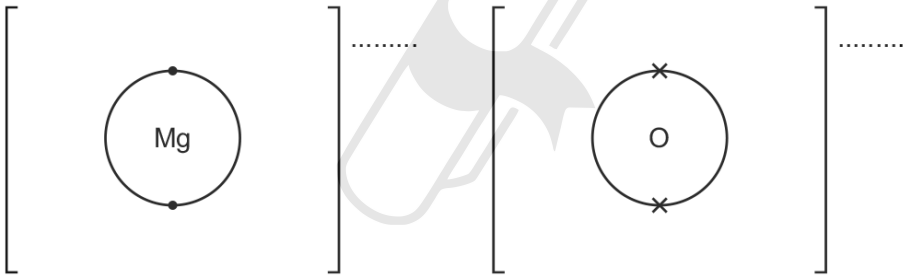
description of bonding .....

.....

.....
[4]

(b) Magnesium oxide, MgO, is formed when magnesium burns in oxygen.

(i) Complete the dot-and-cross diagram to show the electron arrangement of the ions in magnesium oxide.
The inner shells have been drawn.
Give the charges on the ions.



[3]

(ii) Write the chemical equation for the reaction that occurs when magnesium burns in oxygen.

..... [2]

(c) Magnesium oxide also forms when magnesium nitrate, $Mg(NO_3)_2$, is heated strongly. This is an endothermic reaction.

(i) Write the chemical equation for this reaction.

..... [2]

(ii) What type of reaction is this?

..... [1]

(iii) Name **two** other compounds of magnesium that form magnesium oxide when heated.

.....

..... [2]

[Total: 14]

02. 0620_m19_qp_42 Q: 6

This question is about transition elements.

(a) Transition elements are harder and stronger than Group I elements.

Describe **two** other differences in **physical** properties between transition elements and Group I elements.

1 .....

2 .....
[2]

(b) State **one** physical property of transition elements that is similar to Group I elements.

..... [1]

(c) State **two** chemical properties of transition elements.

1 .....

2 .....
[2]

(d) Cobalt is a transition element. Anhydrous cobalt(II) chloride is used to test for water.

State the colour change that occurs when water is added to anhydrous cobalt(II) chloride.

from ..... to .....
[2]

(e) Iron is a transition element.

(i) Which **two** substances react with iron to form rust?

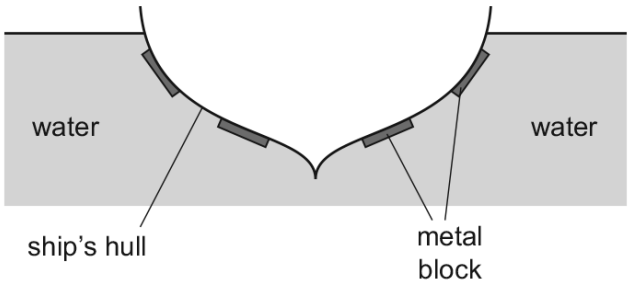
1 .....

2 .....
[2]

(ii) Which metal is used to galvanise iron?

..... [1]

(f) The hull of a ship is made from steel (mainly iron). Metal blocks are placed on the ship's hull to prevent rusting.



Use your knowledge of the reactivity series to explain why:

- magnesium is suitable to use as the metal blocks
- copper is **not** suitable to use as the metal blocks.

.....

.....

..... [2]

(g) Rust contains iron(III) oxide.

Phosphoric acid, H_3PO_4, can be used to remove rust from an iron object and prevent further rusting.

(i) Write a chemical equation for the reaction between iron(III) oxide and phosphoric acid to form iron(III) phosphate and water.

..... [2]

(ii) Iron(III) phosphate is an insoluble salt.

Suggest how the formation of iron(III) phosphate prevents further rusting.

.....

..... [1]

[Total: 15]

03. 0620_s19_qp_42 Q: 7

(a) Displacement reactions occur between metals and metal ions.

Displacement reactions can be used to determine the order of reactivity of metals such as lead (Pb), nickel (Ni), and silver (Ag).

The ionic equation for a displacement reaction is shown.

$$Ni(s) + Pb^{2+}(aq) \rightarrow Pb(s) + Ni^{2+}(aq)$$

The ionic half-equations for this reaction are shown.

$$Ni(s) \rightarrow Ni^{2+}(aq) + 2e^{-}$$

$$Pb^{2+}(aq) + 2e^{-} \rightarrow Pb(s)$$

The ionic half-equations show that electrons are donated by nickel atoms and accepted by lead ions.

(i) Identify the reducing agent in the displacement reaction. Give a reason for your answer.

reducing agent .....

reason .....

[2]

(ii) What is the general term given to the type of reaction in which electrons are transferred from one species to another?

..... [1]

(b) The ionic equation for another displacement reaction is shown.

$$Pb(s) + 2Ag^{+}(aq) \rightarrow 2Ag(s) + Pb^{2+}(aq)$$

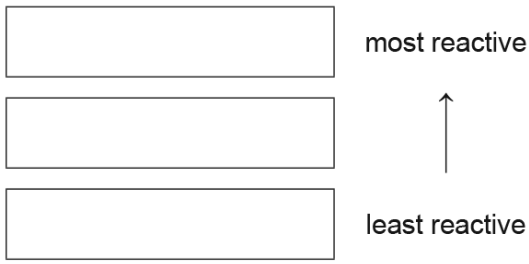
Write the **two** ionic half-equations for this reaction.

1 .....

2 .....

[2]

(c) Use the information in **(a)** and **(b)** to put the **three** metals lead, nickel and silver in order of reactivity.



[1]

(d) Nickel is a transition element. Nickel is stronger than sodium.

Describe **two** other differences in the physical properties of nickel and sodium.

1 .....

2 .....

[2]

(e) Predict **one** difference in the appearance of aqueous solutions of nickel compounds compared to aqueous solutions of sodium compounds.

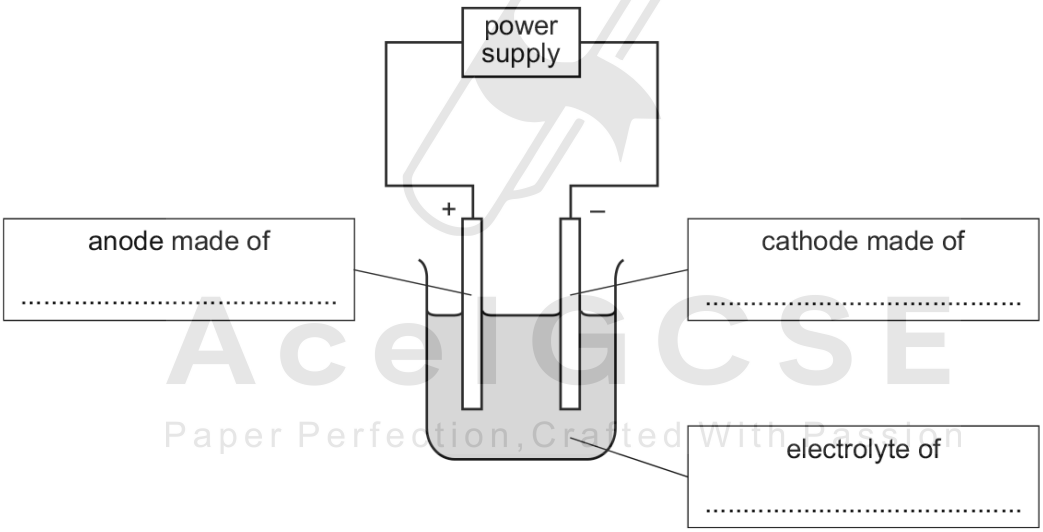
.....

..... [1]

(f) Copper is refined (purified) by electrolysis. Nickel can be refined using a similar method.

(i) The diagram shows the refining of nickel by electrolysis.

Complete the labels in the boxes.



[3]

(ii) Indicate, by writing **N** on the diagram, where nickel is produced. [1]

[Total: 13]

04. 0620_s19_qp_43 Q: 2

Magnesium exists as three isotopes, $^{24}_{12}Mg$, $^{25}_{12}Mg$ and $^{26}_{12}Mg$.

(a) State, in terms of the total numbers of electrons, neutrons and protons, **one** difference and **two** similarities between these magnesium isotopes.

difference .....

similarity 1 .....

similarity 2 .....

[3]

(b) All isotopes of magnesium react with dilute hydrochloric acid to make hydrogen and a salt.

(i) Why do all isotopes of magnesium react in the same way?

.....

.....

..... [2]

(ii) Write a chemical equation for the reaction between magnesium and dilute hydrochloric acid.

..... [2]

(iii) Describe a test for hydrogen.

test .....

result .....

[2]

(c) Magnesium is a metal.

Describe the structure and bonding of metals. Include a labelled diagram in your answer.

.....

.....

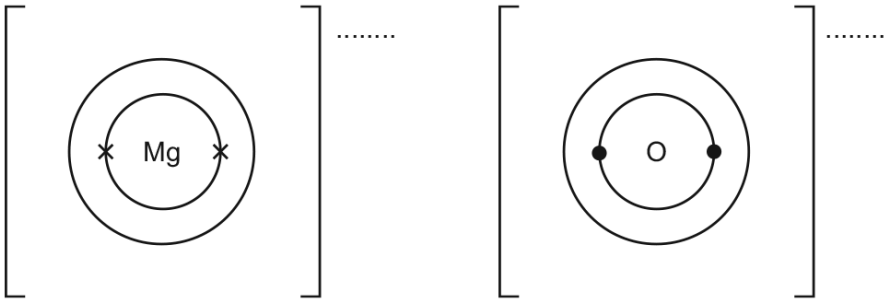
.....

.....

[3]

(d) Magnesium reacts with oxygen to form the ionic compound magnesium oxide.

(i) Complete the dot-and-cross diagrams to show the electronic structures of the ions in magnesium oxide. Show the charges on the ions.



[3]

(ii) Magnesium oxide melts at 2853 °C.

Why does magnesium oxide have a high melting point?

.....

..... [1]

(iii) Explain why molten magnesium oxide can conduct electricity.

.....

.....

..... [1]

[Total: 17]

05. 0620_s19_qp_43 Q: 3

(a) (i) Sodium is in Group I of the Periodic Table.

Describe **two** physical properties of sodium which are different from the physical properties of transition elements such as copper.

1 .....

.....

2 .....

.....

[2]

(ii) Sodium reacts rapidly with water.

Give **one** observation made when sodium is added to water.

..... [1]

(b) Some car airbags contain sodium azide.
When a car airbag is used the sodium azide, NaN_3, decomposes.
The products are nitrogen and sodium.

The equation for the decomposition of sodium azide is shown.

$$2NaN_3(s) \rightarrow 2Na(l) + 3N_2(g)$$

Calculate the mass, in g, of sodium azide needed to produce 144 dm^3 of nitrogen using the following steps.

- Calculate the number of moles in 144 dm^3 of N_2 measured at room temperature and pressure.

moles of N_2 = ... mol

- Determine the number of moles of NaN_3 needed to produce this number of moles of N_2.

moles of NaN_3 = ... mol

- Calculate the relative formula mass, M_r, of NaN_3.

M_r = ...

- Calculate the mass of NaN_3 needed to produce 144 dm^3 of N_2.

..... g
[4]

(c) Some airbags contain silicon(IV) oxide.
When the airbag is used sodium oxide is formed.

Oxides can be classified as acidic, amphoteric, basic or neutral.

Classify each of these oxides:

sodium oxide .....

silicon(IV) oxide. .....
[2]

(d) Lead(II) azide is insoluble in water. Solid lead(II) azide can be made in a precipitation reaction between aqueous lead(II) nitrate and aqueous sodium azide.
Lead(II) azide has the formula $Pb(N_3)_2$.

(i) Deduce the formula of the azide ion.

..... [1]

(ii) Complete the chemical equation for the reaction between aqueous lead(II) nitrate and aqueous sodium azide to form solid lead(II) azide and aqueous sodium nitrate. Include state symbols.

$Pb(NO_3)_2(aq)$ + ... $NaN_3(aq) \rightarrow Pb(N_3)_2$(.....) + ...(.....)
[2]

(iii) Describe how you could obtain a sample of lead(II) azide that is **not** contaminated with any soluble salts from the reaction mixture.

.....

.....

.....

..... [2]

(e) An organic compound made from sodium azide has the composition by mass: 49.5% carbon, 7.2% hydrogen and 43.3% nitrogen.

Calculate the empirical formula of the organic compound.

[3]

[Total: 17]

06. 0620_w18_qp_42 Q: 2

Magnesium, calcium and strontium are Group II elements.

(a) Complete the table to show the arrangement of electrons in a calcium atom.

shell number	1	2	3	4
number of electrons				

[1]

(b) Describe how the arrangement of electrons in a strontium atom is:

(i) similar to the arrangement of electrons in a calcium atom

.....

.....

(ii) different from the arrangement of electrons in a calcium atom.

.....

.....

[2]

(c) Calcium reacts with cold water to form two products:

- a colourless gas, **P**, which 'pops' with a lighted splint
- a weakly alkaline solution, **Q**, which turns milky when carbon dioxide is bubbled through it.

(i) Name gas **P**.

..... [1]

(ii) Identify the ion responsible for making solution **Q** alkaline.

..... [1]

(iii) Suggest the pH of solution **Q**.

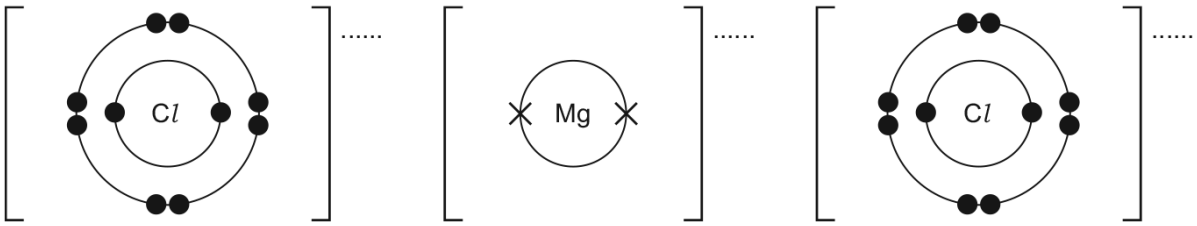
..... [1]

(iv) Write a chemical equation for the reaction of calcium with cold water.

..... [2]

(d) Magnesium reacts with chlorine to form magnesium chloride, $MgCl_2$. Magnesium chloride is an ionic compound.

(i) Complete the diagrams to show the electronic structures of the ions in magnesium chloride. Show the charges on the ions.



[3]

(ii) Give **three** physical properties that are typical of ionic compounds such as $MgCl_2$.

1 .....

2 .....

3 .....

[3]

(e) Aqueous magnesium chloride is added to aqueous silver nitrate. A white precipitate forms.

Write an **ionic** equation for this reaction. Include state symbols.

..... [2]

[Total: 16]

07. 0620_s17_qp_42 Q: 4

Nickel, copper and zinc are three consecutive elements in the Periodic Table.

(a) Nickel and copper are transition elements.

State **three** chemical properties of transition elements.

.....

.....

..... [3]

(b) Copper(II) oxide is a basic oxide but zinc oxide is an amphoteric oxide. Both oxides are insoluble in water.

You are provided with a mixture of solid copper(II) oxide and solid zinc oxide. Describe how you would obtain a sample of copper(II) oxide from this mixture.

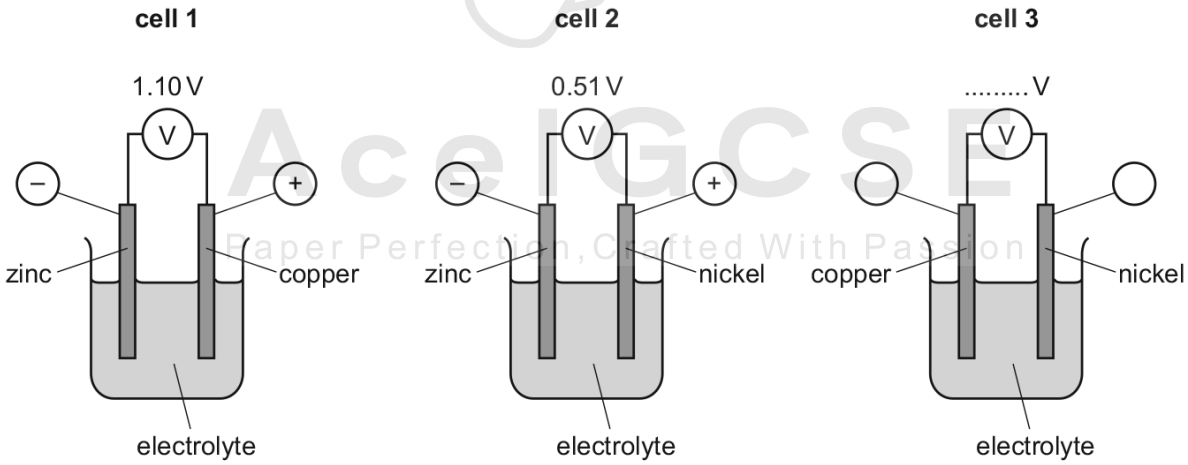
.....

.....

.....

..... [3]

(c) Three cells are set up each using two metals.



(i) Write the ionic half-equation for the reaction occurring at the zinc electrode in **cell 1**.

..... [2]

(ii) Put the **three** metals, copper, nickel and zinc, in order of reactivity.

most reactive .....

↓ .....

least reactive .....

[1]

(iii) Complete the labelling in **cell 3** by writing the polarity (+/–) of each electrode in the circles and calculating the reading on the voltmeter. [2]

[Total: 11]

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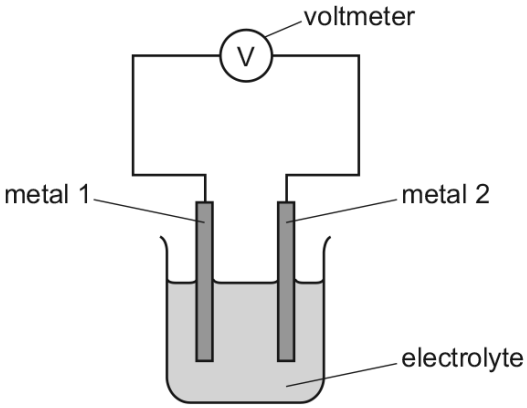
08. 0620_s17_qp_43 Q: 5

The diagram shows a simple cell.



The simple cell was used with different metals as electrodes. The voltages were recorded in the table.

- If the voltage measured is positive then metal 2 is more reactive than metal 1.
- If the voltage measured is negative then metal 1 is more reactive than metal 2.

		metal 2				
		beryllium	cobalt	nickel	silver	vanadium
metal 1	beryllium	0.0 V	–1.6 V	–1.6 V	not measured	–0.7 V
	cobalt		0.0 V	0.0 V	–1.1 V	0.9 V
	nickel			0.0 V	–1.1 V	0.9 V
	silver				0.0 V	2.0 V
	vanadium					0.0 V

- The more reactive metal is oxidised.
- The bigger the difference in reactivity of the metals, the larger the reading on the voltmeter.

(a) In a simple cell using nickel and silver, the nickel is oxidised.

(i) Define *oxidation* in terms of electrons.

..... [1]

(ii) Nickel forms ions with a charge of +2.

Write an ionic half-equation to show the oxidation of nickel.

..... [1]

(iii) What will happen to the mass of the nickel electrode when the nickel is oxidised?

.....

..... [1]

(b) Use the data in the table to answer the following questions.

(i) Which of the metals in the table is the most reactive?
Explain your answer.

.....

..... [2]

(ii) State which **two** different metals have the same reactivity.

..... [1]

(iii) Predict the voltage produced by a simple cell with beryllium as metal 1 and silver as metal 2.

.....

..... [2]

(c) Describe how the simple cell in the diagram can be used to show that magnesium is more reactive than beryllium. Explain your answer.

.....

.....

.....

..... [2]

[Total: 10]

09. 0620_w17_qp_41 Q: 5

(a) Solid copper(II) carbonate undergoes thermal decomposition. One of the products of the thermal decomposition is copper(II) oxide.

(i) State the colour change of the solid seen during the reaction.

start colour .....

end colour .....

[1]

(ii) Write a chemical equation for the thermal decomposition of copper(II) carbonate.

..... [1]

(b) Copper(II) carbonate reacts with dilute nitric acid. One of the products of the reaction is a solution of copper(II) nitrate.

(i) Describe tests for copper(II) ions and nitrate ions. Include the results of the tests.

copper(II) ions .....

.....

.....

nitrate ions .....

.....

.....

[4]

(ii) Copper(II) nitrate undergoes thermal decomposition.

Balance the chemical equation for the thermal decomposition of copper(II) nitrate.

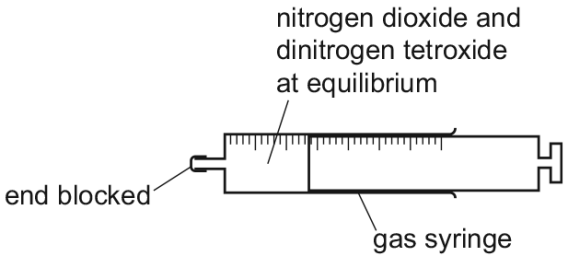
.....$Cu(NO_3)_2$ → .....CuO + ...NO_2 + ...O_2

[1]

(c) Nitrogen dioxide, NO_2, exists in equilibrium with dinitrogen tetroxide, N_2O_4.
Nitrogen dioxide is brown and dinitrogen tetroxide is colourless.

$$\underset{\text{brown}}{2NO_2(g)} \rightleftharpoons \underset{\text{colourless}}{N_2O_4(g)}$$

(i) A sample of nitrogen dioxide and dinitrogen tetroxide at equilibrium was placed in a closed gas syringe.
The syringe plunger was pushed in. This increased the pressure in the gas syringe. The temperature was kept constant.



State how the colour of the gas in the syringe changed. Explain your answer in terms of the position of the equilibrium.

.....

.....

.....

..... [3]

(ii) A sealed tube containing nitrogen dioxide and dinitrogen tetroxide at equilibrium was cooled in an ice bath at constant pressure. The contents of the tube became paler.

Suggest an explanation for this observation in terms of the position of the equilibrium.

.....

.....

..... [2]

[Total: 12]

10. 0620_w17_qp_43 Q: 5

(a) (i) Name the products formed when sodium nitrate is heated.

..... [2]

(ii) When copper(II) nitrate, $Cu(NO_3)_2$, undergoes thermal decomposition, three products are formed. One of the products is nitrogen dioxide, NO_2.

Write a chemical equation for the thermal decomposition of copper(II) nitrate.

..... [2]

(b) The chemical equation shows the equilibrium between dinitrogen tetroxide (N_2O_4, a colourless gas) and nitrogen dioxide (NO_2, a brown gas).

$$\underset{\text{colourless}}{N_2O_4(g)} \rightleftharpoons \underset{\text{brown}}{2NO_2(g)}$$

A mixture of dinitrogen tetroxide and nitrogen dioxide is allowed to reach equilibrium in a closed gas syringe.

(i) In chemistry, what is meant by the term *equilibrium*?

.....

.....

..... [2]

(ii) If the equilibrium mixture is heated at constant pressure, a darker brown colour is seen inside the gas syringe.

What does this information indicate about the decomposition of dinitrogen tetroxide?
Explain your answer in terms of the position of the equilibrium.

.....

.....

..... [2]

(iii) Suggest what you would see if the pressure on the equilibrium mixture were increased at constant temperature.
Explain your answer in terms of the position of the equilibrium.

.....

.....

..... [2]

[Total: 10]

11. 0620_m16_qp_42 Q: 2

Rubidium, Rb, is a Group I element. It has similar physical and chemical properties to the other elements in Group I.

(a) Predict how many electrons there are in the outer shell of a rubidium atom.

..... [1]

(b) Predict **one** physical property of rubidium which is the same as that of a transition element such as iron.

..... [1]

(c) Predict **two** physical properties of rubidium which are different to those of a transition element such as iron.

.....

..... [2]

(d) When rubidium is added to cold water a reaction occurs.

(i) Suggest **two** observations that would be made when rubidium is added to cold water.

.....

..... [2]

(ii) What would be the colour of the solution if methyl orange was added to it after the reaction?

..... [1]

(iii) Write a chemical equation for the reaction between rubidium and water.

..... [2]

(iv) Put the Group I elements, caesium, lithium, potassium, rubidium and sodium in their order of reactivity with water. Put the most reactive element first.

most reactive ⟶ least reactive

[1]

(v) Suggest **one** safety measure that should be used when rubidium is added to cold water.

..... [1]

(e) The phosphate ion has the formula PO_4^{3-}.

Deduce the formula of rubidium phosphate.

..... [1]

[Total: 12]

12. 0620_m15_qp_32 Q: 6

A student is told to produce the maximum amount of copper from a mixture of copper and copper(II) carbonate.

The student adds the mixture to an excess of dilute sulfuric acid in a beaker and stirs the mixture with a glass rod. The copper(II) carbonate reacts with the sulfuric acid, forming a solution of copper(II) sulfate but the copper does not react with the sulfuric acid.

The student then

- removes the unreacted copper from the mixture,
- converts the solution of copper(II) sulfate into copper by a series of reactions.

(a) Describe **two** things that the student would observe when the mixture is added to the dilute sulfuric acid.

.....

..... [2]

(b) Describe how the student can produce pure dry copper from the mixture of copper and copper(II) sulfate solution.

.....

.....

.....

..... [3]

(c) The student then adds sodium hydroxide solution to the copper(II) sulfate solution to produce copper(II) hydroxide.

(i) Describe what the student would observe.

..... [1]

(ii) Write an **ionic** equation for this reaction.

..... [1]

(d) After separating the copper(II) hydroxide from the mixture, the copper(II) hydroxide is heated strongly. The copper(II) hydroxide decomposes into copper(II) oxide and steam.

(i) Write an equation for the decomposition of copper(II) hydroxide. Include state symbols.

..... [2]

(ii) Name a non-metallic element that can be used to convert copper(II) oxide into copper.

..... [1]

[Total: 10]

13. 0620_s15_qp_33 Q: 5

The law of constant composition states that all pure samples of a compound contain the same elements in the same proportion by weight.

A typical experiment to test this law is to prepare the same compound by different methods and then show that the samples have the same composition.

Methods of making copper(II) oxide include:

- heating copper carbonate,
- heating copper hydroxide,
- heating copper nitrate,
- heating copper foil in air.

(a) Complete the following equations.

(i) $CuCO_3 \rightarrow$ ..... + ... [1]

(ii) $Cu(OH)_2 \rightarrow$ ..... + ... [1]

(iii) $2Cu(NO_3)_2 \rightarrow$ ..... + $4NO_2$ + ... [2]

(b) Copper oxide can be reduced to copper by heating in hydrogen.

(i) What colour change would you observe during the reduction?

..... [1]

(ii) Explain why the copper must be allowed to cool in hydrogen before it is exposed to air.

..... [2]

(iii) Name another gas which can reduce copper(II) oxide to copper.

..... [1]

(iv) Name a solid which can reduce copper(II) oxide to copper.

..... [1]

(c) The table below shows the results obtained by reducing the copper(II) oxide produced by different methods to copper.

(i) Complete the table.

source of copper(II) oxide	mass of copper(II) oxide / g	mass of copper / g	percentage copper / %
$CuCO_3$	2.37	1.89	79.7
$Cu(OH)_2$	2.51	1.99	
$Cu(NO_3)_2$	2.11	1.68	
Cu and O_2	2.29	1.94	

[2]

(ii) One of the samples of copper(II) oxide is impure.

Identify this sample and suggest an explanation why the percentage of copper in this sample is bigger than in the other three samples.

.....

..... [2]

[Total: 13]

14. 0620_w15_qp_33 Q: 6

A reactivity series of metals is given below.

most reactive

↓

least reactive

metal name	symbol
sodium	Na
lithium	Li
magnesium	Mg
zinc	Zn
manganese	Mn
iron	Fe
copper	Cu
rhodium	Rh

(a) Which **two** metals will react most vigorously with cold water?

..... [1]

(b) Which **two** metals will not react with dilute hydrochloric acid?

..... [1]

(c) Deduce the formula of iron(III) sulfate.

..... [1]

(d) What is the formula of a magnesium ion?

..... [1]

(e) Describe a test-tube experiment which will show that manganese is more reactive than copper.

.....

.....

..... [3]

(f) Manganese is a typical transition metal.

Predict **three** physical and **two** chemical properties of this metal.

physical properties

.....

.....

.....

chemical properties

.....

.....

[5]

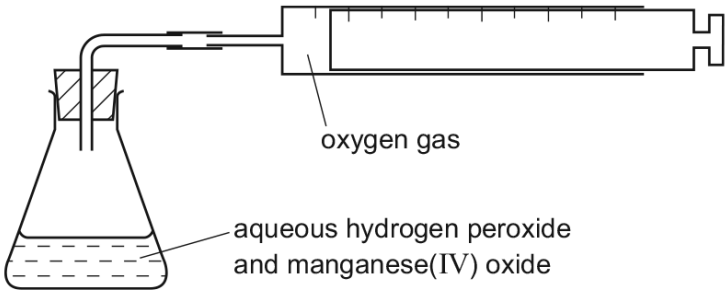
[Total: 12]

15. 0620_s14_qp_31 Q: 6

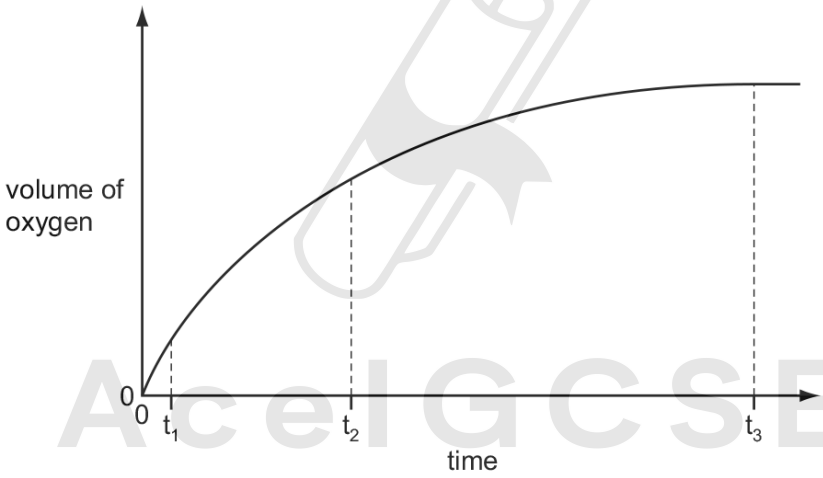
Hydrogen peroxide decomposes to form water and oxygen. This reaction is catalysed by manganese(IV) oxide.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The rate of this reaction can be investigated using the following apparatus.



40 cm^3 of aqueous hydrogen peroxide was put in the flask and 0.1 g of small lumps of manganese(IV) oxide was added. The volume of oxygen collected was measured every 30 seconds. The results were plotted to give the graph shown below.



(a) (i) How do the rates at times t_1, t_2 and t_3 differ?

.....

..... [2]

(ii) Explain the trend in reaction rate that you described in **(a)(i)**.

.....

.....

..... [2]

(b) The experiment was repeated using 0.1 g of finely powdered manganese(IV) oxide. All the other variables were kept the same.

(i) On the axes opposite, sketch the graph that would be expected. [2]

(ii) Explain the shape of this graph. .....

.....

.....

..... [2]

(c) Describe how you could show that the catalyst, manganese(IV) oxide, was not used up in the reaction. Manganese(IV) oxide is insoluble in water.

.....

.....

.....

.....

..... [4]

(d) In the first experiment, the maximum volume of oxygen produced was 96 cm^3 measured at r.t.p. Calculate the concentration of the aqueous hydrogen peroxide in mol / dm^3.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

number of moles of O_2 formed = ... [1]

number of moles of H_2O_2 in 40 cm^3 of solution = ... [1]

concentration of the aqueous hydrogen peroxide in mol / dm^3 = ...

..... [1]

[Total: 15]

16. 0620_s14_qp_31 Q: 7

One way of establishing a reactivity series is by displacement reactions.

(a) A series of experiments was carried out using the metals lead, magnesium, zinc and silver. Each metal was added in turn to aqueous solutions of the metal nitrates.

The order of reactivity was found to be:

magnesium	most reactive
zinc	↓
lead	
silver	least reactive

(i) Complete the table.

✓ = reacts
✗ = does not react

	metal			
aqueous solution	lead Pb	magnesium Mg	zinc Zn	silver Ag
lead(II) nitrate		✓	✓	✗
magnesium nitrate				
zinc nitrate				
silver nitrate				

[3]

(ii) Displacement reactions are redox reactions.
On the following equation, draw a **ring** around the reducing agent and an **arrow** to show the change which is oxidation.

$$Zn + Pb^{2+} \rightarrow Zn^{2+} + Pb$$

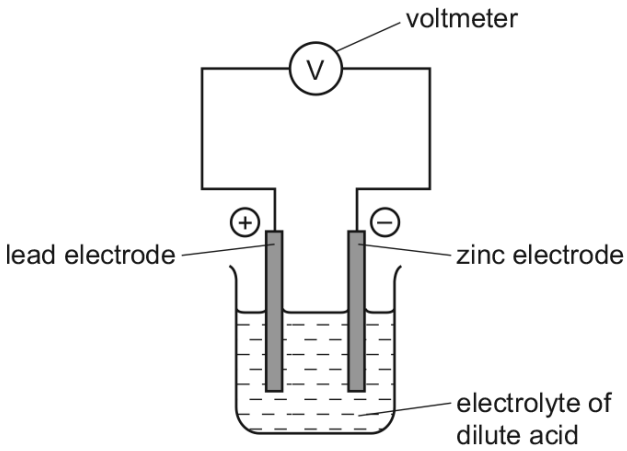
[2]

(iii) Complete the following ionic equation.

$$Zn + 2Ag^{+} \rightarrow \text{.....} + \text{.....}$$

[1]

(b) Another way of determining the order of reactivity of metals is by measuring the voltage and polarity of simple cells. The polarity of a cell is shown by which metal is the positive electrode and which metal is the negative electrode. An example of a simple cell is shown below.



(i) Mark on the above diagram the direction of the electron flow. [1]

(ii) Explain, in terms of electron transfer, why the more reactive metal is always the negative electrode.

.....

.....

..... [2]

(iii) The following table gives the polarity of cells using the metals zinc, lead, copper and manganese.

cell	electrode 1	polarity	electrode 2	polarity
A	zinc	–	lead	+
B	manganese	–	lead	+
C	copper	+	lead	–

What information about the order of reactivity of these four metals can be deduced from the table?

.....

.....

..... [2]

(iv) What additional information is needed to establish the order of reactivity of these four metals using cells?

..... [1]

[Total: 12]

17. 0620_w14_qp_33 Q: 6

Rubidium and strontium are very reactive metals at the top of the reactivity series. Because their ions have different charges, their compounds behave differently when heated.

(a) The formulae of the ions of these two elements are Rb^+ and Sr^{2+}.
Explain why these metals, which are in different groups, form ions which have different charges.

.....

..... [2]

(b) Strontium carbonate is similar to calcium carbonate. It is insoluble in water and it decomposes when heated. Rubidium carbonate is soluble in water and does not decompose when heated.

(i) Describe a method to prepare a pure sample of the insoluble salt, strontium carbonate, by precipitation.

.....

.....

.....

.....

..... [4]

(ii) Complete the equation for the decomposition of strontium carbonate.

$$SrCO_3 \rightarrow \text{.....} + \text{.....}$$

[1]

(c) Metal nitrates decompose when heated.

(i) Rubidium nitrate decomposes as follows:

$$2RbNO_3 \rightarrow 2RbNO_2 + O_2$$

What is the name of the compound $RbNO_2$?

..... [1]

(ii) The nitrates of most other metals decompose in a different way.
Complete the equation for the decomposition of strontium nitrate.

$$\text{.....}Sr(NO_3)_2 \rightarrow \text{.....} + 4NO_2 + \text{.....}$$

[2]

[Total: 10]

18. 0620_s13_qp_31 Q: 5

The reactivity series shows the metals in order of reactivity.

(a) The reactivity series can be established using displacement reactions. A piece of zinc is added to aqueous lead nitrate. The zinc becomes coated with a black deposit of lead.

$$Zn + Pb^{2+} \rightarrow Zn^{2+} + Pb$$

Zinc is more reactive than lead.

The reactivity series can be written as a list of ionic equations.

.....	→	.....	+	.....	most reactive metal : the best reductant (reducing agent)
Zn	→	Zn^{2+}	+	$2e^-$	
Fe	→	Fe^{2+}	+	$2e^-$	
Pb	→	Pb^{2+}	+	$2e^-$	
Cu	→	Cu^{2+}	+	$2e^-$	
Ag	→	Ag^+	+	e^-	

(i) In the space at the top of the list, write an ionic equation for a metal which is more reactive than zinc. [1]

(ii) Write an ionic equation for the reaction between aqueous silver(I) nitrate and zinc.

..... [2]

(iii) Explain why the positive ions are likely to be oxidants (oxidising agents).

..... [1]

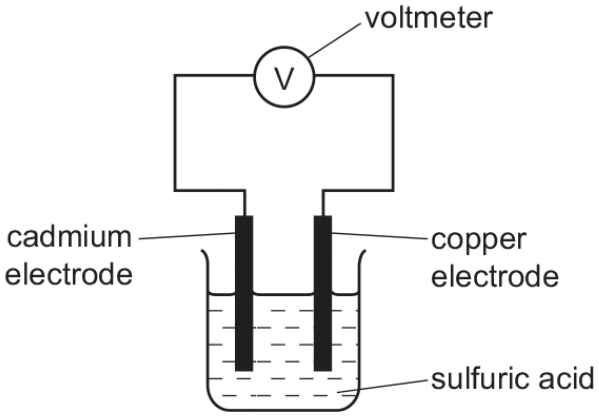
(iv) Deduce which ion is the best oxidant (oxidising agent).

..... [1]

(v) Which ion(s) in the list can oxidise lead metal?

..... [1]

(b) A reactivity series can also be established by measuring the voltage of simple cells. The diagram shows a simple cell.



Results from cells using the metals tin, cadmium, zinc and copper are given in the table below.

cell	electrode 1 positive electrode	electrode 2 negative electrode	voltage / volts
1	copper	cadmium	0.74
2	copper	tin	0.48
3	copper	zinc	1.10

Write the four metals in order of increasing reactivity and explain how you used the data in the table to determine this order.

.....

.....

..... [3]

[Total: 9]

19. 0620_s13_qp_33 Q: 5

All metal nitrates decompose when heated. A few form a nitrite and oxygen. Most form the metal oxide, oxygen and a brown gas called nitrogen dioxide.

(a) (i) Name a metal whose nitrate decomposes to form the metal nitrite and oxygen.

..... [1]

(ii) Complete the equation for the action of heat on lead(II) nitrate.

.....$Pb(NO_3)_2$ → ..... + ...NO_2 + O_2 [2]

(iii) Suggest why the nitrate of the metal, named in **(a)(i)**, decomposes less readily than lead(II) nitrate.

.....

..... [2]

(b) Almost all samples of nitrogen dioxide are an equilibrium mixture of nitrogen dioxide, NO_2, and dinitrogen tetroxide, N_2O_4.

$$\underset{\text{dark brown}}{2NO_2(g)} \underset{\text{reverse reaction}}{\overset{\text{forward reaction}}{\rightleftharpoons}} \underset{\text{colourless}}{N_2O_4(g)}$$

In the forward reaction, a bond forms between the two nitrogen dioxide molecules.

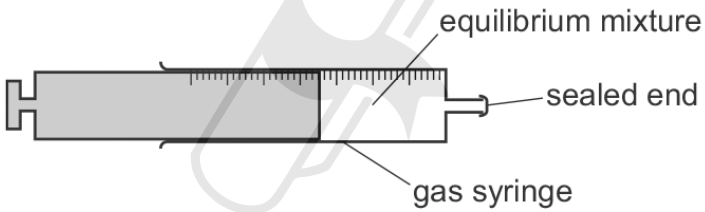
$$NO_2 + NO_2 \rightarrow O_2N{-}NO_2$$

(i) Explain the term *equilibrium mixture*.

.....

..... [1]

(ii) The syringe contains a sample of the equilibrium mixture. The plunger was pulled back reducing the pressure.
How would the colour of the gas inside the syringe change? Give an explanation for your answer.



.....

.....

..... [3]

(iii) A sealed tube containing an equilibrium mixture of nitrogen dioxide and dinitrogen tetroxide was placed in a beaker of ice cold water.
The colour of the mixture changed from brown to pale yellow.

Is the forward reaction exothermic or endothermic? Give an explanation for your choice.

.....

..... [2]

(iv) What other piece of information given in the equation supports your answer to **(iii)**?

$$NO_2 + NO_2 \rightarrow O_2N{-}NO_2$$

..... [1]

20. 0620_w13_qp_31 Q: 2

(a) Give **three** differences in physical properties between the Group I metal, potassium, and the transition element, iron.

1. .....

2. .....

3. ..... [3]

(b) The following metals are in order of reactivity.

potassium
zinc
copper

For those metals which react with water or steam, name the products of the reaction, otherwise write 'no reaction'.

potassium .....

.....

zinc .....

.....

copper .....

..... [5]

[Total: 8]

21. 0620_w13_qp_32 Q: 6

The following reactivity series shows both familiar and unfamiliar elements in order of decreasing reactivity. Each element is represented by a redox equation.

$$Rb \rightleftharpoons Rb^{+} + e^{-}$$
$$Mg \rightleftharpoons Mg^{2+} + 2e^{-}$$
$$Mn \rightleftharpoons Mn^{2+} + 2e^{-}$$
$$Zn \rightleftharpoons Zn^{2+} + 2e^{-}$$
$$H_2 \rightleftharpoons 2H^{+} + 2e^{-}$$
$$Cu \rightleftharpoons Cu^{2+} + 2e^{-}$$
$$Hg \rightleftharpoons Hg^{2+} + 2e^{-}$$

Two of the uses of the series are to predict the thermal stability of compounds of the metals and to explain their redox reactions.

(a) Most metal hydroxides decompose when heated.

(i) Complete the equation for the thermal decomposition of copper(II) hydroxide.

$Cu(OH)_2 \rightarrow$ ..... + ... [1]

(ii) Choose a metal from the above series whose hydroxide does not decompose when heated.

..... [1]

(b) (i) Define in terms of electron transfer the term *oxidation*.

..... [1]

(ii) Explain why the positive ions in the above equations are oxidising agents.

.....

..... [1]

(c) (i) Which metals in the series above do not react with dilute acids to form hydrogen?

..... [1]

(ii) Describe an experiment which would confirm the prediction made in **(c)(i)**.

.....

..... [1]

(d) (i) Which metal in the series above can form a negative ion which gives a pink/purple solution in water?

..... [1]

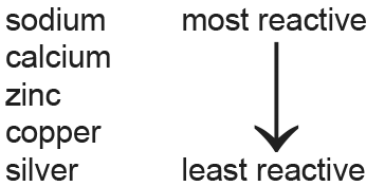
(ii) Describe what you would observe when zinc, a reducing agent, is added to this pink/purple solution.

..... [1]

[Total: 8]

22. 0620_s12_qp_31 Q: 5

Reactive metals tend to have unreactive compounds. The following is part of the reactivity series.



(a) Sodium hydroxide and sodium carbonate do not decompose when heated.
The corresponding calcium compounds do decompose when heated.
Complete the following equations.

calcium carbonate → ..... + ...
....

$Ca(OH)_2$ → ..... + ... [2]

(b) All nitrates decompose when heated.

(i) The equation for the thermal decomposition of silver(I) nitrate is given below.

$$2AgNO_3 \rightarrow 2Ag + 2NO_2 + O_2$$

What are the products formed when copper(II) nitrate is heated?

..... [1]

(ii) Complete the equation for the action of heat on sodium nitrate.

.....$NaNO_3$ → ..... + ...

[2]

(c) Which of the metals in the list on page 5 have oxides which are not reduced by carbon?

..... [1]

(d) Choose from the list on page 5, metals whose ions would react with zinc.

..... [2]

[Total: 8]

01. 0620_s20_ms_41 Q: 2

(a)	metallic (bonding)	1
	sea of electrons	1
	positive ions	1
	attraction between	1
(b)(i)	Mg octet of eight dots	1
	O octet of six crosses and two dots.	1
	correct charges on both ions	1
(b)(ii)	$2Mg + O_2 \rightarrow 2MgO$ M1 species M2 balancing	2
(c)(i)	$2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$ M1 product species M2 balancing	2
(c)(ii)	(thermal) decomposition	1
(c)(iii)	magnesium carbonate	1
	magnesium hydroxide	1

02. 0620_m19_ms_42 Q: 6

(a)	**M1** Transition element has higher melting point / high boiling point **ORA**(1) **M2** Transition element has higher density **ORA**(1)	2
(b)	good conduction of heat or electricity **OR** malleability **OR** ductility	1
(c)	1 mark each for any two of: □ catalyst □ more than one or different or variable oxidation state / oxidation number / valency □ coloured **compounds** / coloured **ions**	2

(d)	from blue(1) to pink(1)	2
(e)(i)	**M1** oxygen(1) **M2** water(1)	2
(e)(ii)	zinc / Zn	1
(f)	**M1** magnesium above iron / steel in the reactivity series **ORA** / magnesium more reactive than iron / steel **ORA**(1) **M2** copper below iron / steel in the reactivity series **ORA** / copper less reactive than iron **ORA**(1)	2
(g)(i)	$Fe_2O_3 + 2H_3PO_4 \rightarrow 2FePO_4 + 3H_2O$ **M1** $FePO_4$ anywhere(1) **M2** The whole equation correct(1)	2
(g)(ii)	iron(III) phosphate acts as a barrier which prevents contact between iron and water or air / oxygen	1

03. 0620_s19_ms_42 Q: 7

(a)(i)	**M1** Ni / Nickel (1) **M2** (it) loses or donates electrons (1)	**2**
(a)(ii)	redox	**1**
(b)	**M1** $Pb \rightarrow Pb^{2+} + 2e^{(-)}$ / (1) **M2** $Ag^{+} + e^{(-)} \rightarrow Ag$ (1)	**2**
(c)	most reactive nickel / Ni lead / Pb least reactive silver / Ag	**1**
(d)	**nickel has** **M1** higher density (1) **ORA** **nickel has** **M2** higher melting point / boiling point (1) **ORA**	**2**
(e)	solutions of nickel compounds are coloured **ORA**	**1**
(f)(i)	**M1** electrolyte aqueous or solution of named nickel salt (1) **M2 anode** impure nickel (1) **M3 cathode** pure nickel (1)	**3**
(f)(ii)	nickel produced at cathode under the liquid surface (1)	**1**

04. 0620_s19_ms_43 Q: 2

(a)	difference: **M1 (**number of) neutrons similarities: **M2** (number of) protons **M3** (number of) electrons	**3**
(b)(i)	**M1** same number of electrons **M2** (same number of) electrons in outer shell	**2**
(b)(ii)	$Mg + 2 HCl \rightarrow MgCl_2 + H_2$ **M1** $MgCl_2$ as product **M2** fully correct equation	**2**
(b)(iii)	**M1** Test: lighted / burning splint **M2** Result: (squeaky) pop	**2**

(c)	**M1** (lattice of) positive ions / cations **M2** (delocalised / sea of) electrons **M3** attraction / attract between positive and negative	**3**
(d)(i)	**M1** magnesium ion second shell shown containing 8 electrons shown as X **M2** oxide ion second shell shown containing 8 electrons, two as X and six as ● **M3** charges: magnesium ion as 2+ **and** oxide as 2-	**3**
(d)(ii)	strong forces of **attraction** (between oppositely charged ions)	**1**
(d)(iii)	ions / Mg^{2+} **and** O^{2-} / anions **and** cations can move (throughout the structure)	**1**

05. 0620_s19_ms_43 Q: 3

(a)(i)	any two from: □ low melting point **or** low boiling point □ soft □ low density	**max 2**
(a)(ii)	any one from: □ fizz / bubbles □ moves □ floats □ melts / forms a ball □ gets smaller / disappears	**max 1**

(b)	mass sodium azide = 260 (g) □ Moles N_2 = (144 / 24 =) 6 □ Moles NaN_3 = (6 □ 2 / 3 =) 4 □ M_r NaN_3 = 65 □ (4 □ 65 =) 260	**4**
(c)	**M1** (sodium oxide) basic **M2** (silicon dioxide) acidic	**2**
(d)(i)	N_3^-	**1**
(d)(ii)	**M1** state symbols on right correct (s) then (aq) **M2** $(Pb(NO_3)_2 +)$ 2 $(NaN_3) \rightarrow (Pb(N_3)_2 +)$ $2NaNO_3$	**2**
(d)(iii)	**M1** filter **M2** wash with water	**2**
(e)	**M1** 49.5 / 12 7.2 / 1 43.3 / 14 OR 4.125 7.2 3.093…. **M2** 1.33 : 2.33 : 1 OR 4 : 7 : 3 **M3** $C_4H_7N_3$	**3**

06. 0620_w18_ms_42 Q: 2

(a)	2 : 8 : 8 : 2	**1**
(b)(i)	M1 Same number of (**or** 2) outer electrons	**2**
(b)(ii)	M2 (Sr has) outer electrons are in the 5th shell	
(c)(i)	Hydrogen	**1**

(c)(ii)	Hydroxide OR OH^-	1
(c)(iii)	$7 < pH \leqslant 12$	1
(c)(iv)	$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$ M1 $Ca(OH)_2$ M2 Rest of equation	2
(d)(i)	M1 Mg shown with new outer shell with 8 crosses; M2 Both C*l* atoms with a new outer shell with 7 dots and 1 cross; M3 '2+' charge on Mg **and** '–' charge on each C*l*;	3
(d)(ii)	M1 *Physical constants mark* High melting point or high boiling point M2 *Solubility mark* Dissolve in water M3 *Electrical conductivity mark* Conduct (electricity) when molten **or** conduct (electricity) in aqueous solution	3
(e)	$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ M1 Species M2 States	2

07. 0620_s17_ms_42 Q: 4

(a)	any 3 from: □ catalyst □ more than one / variable oxidation state / oxidation number / valency □ form coloured **compounds** / coloured **ions** □ forms complex ions / complexes	3
(b)	add sodium hydroxide (solution) / NaOH / potassium hydroxide (solution) / KOH	1
	zinc oxide dissolves / reacts **OR** copper(II) oxide does not dissolve / react	1
	filter / decant / centrifuge (copper(II) oxide)	1
(c)(i)	$Zn \rightarrow Zn^{2+} + 2e / 2e^-$ **M1** formula of Zn^{2+} on the right-hand side **M2** equation fully correct	2
(c)(ii)	zinc / Zn nickel / Ni copper / Cu	1
(c)(iii)	copper (+) and nickel (–)	1
	0.59 V	1

08. 0620_s17_ms_43 Q: 5

(a)(i)	loss (of electrons)	1
(a)(ii)	$Ni \rightarrow Ni^{2+} + 2e^-$	1
(a)(iii)	goes down / gets less / decreases / lower / smaller	1
(b)(i)	beryllium	1
	most negative voltage with any (named) metal **OR** biggest voltage with cobalt / nickel	1
(b)(ii)	cobalt **AND** nickel	1
(b)(iii)	– sign	1
	2.7	1
(c)	(set up cell) using magnesium and beryllium (electrodes)	1
	voltage positive if magnesium is metal 2	1
	OR	
	(set up cells) using both magnesium and beryllium with the same metal as the other electrode	1
	larger (magnitude) voltages with magnesium	1
	OR	
	use magnesium with a different metal and compare to a reference value in a table	1
	value is more negative than with beryllium, if magnesium is metal 1	1

09. 0620_w17_ms_41 Q: 5

(a)(i)	*start colour:* green *end colour:* black	1
(a)(ii)	$CuCO_3 \rightarrow CuO + CO_2$	1
(b)(i)	(*copper(II) ions)* add sodium hydroxide (solution)	1
	(*copper(II) ions)* blue ppt.	1
	(*nitrate ions*) add aluminium **AND** aqueous sodium hydroxide **AND** warm	1
	ammonia given off / gas turns damp (red) litmus blue	1
(b)(ii)	2 / 2 / 4 / 1	1
(c)(i)	becomes paler	1
	equilibrium moves right	1
	(because) fewer moles (of gas) on right	1
(c)(ii)	equilibrium moved right / more N_2O_4 / less NO_2	1
	(forward) reaction exothermic	1

10. 0620_w17_ms_43 Q: 5

(a)(i)	oxygen / O_2	1
	sodium nitrite / sodium nitrate(III) / $NaNO_2$	1
(a)(ii)	$2Cu(NO_3)_2 \rightarrow 2CuO + O_2 + 4NO_2$ **M1** CuO **M2** rest of equation fully correct	2
(b)(i)	reversible reaction in which the **rate** of the forward reaction **equals** the **rate** of the backward reaction	1
	concentration of all reactants and products becomes constant / does not change	1
(b)(ii)	forward reaction is endothermic	1
	(increased temperature) causes equilibrium to shift to the right / to shift in the endothermic direction / to form more nitrogen dioxide / to form more product(s)	1
(b)(iii)	less brown / light**er** / paler / colour fades	1
	more molecules / moles / volume on the right **ORA** **OR** equilibrium shifts in the direction of **fewer** molecules / moles / lower volume	1

11. 0620_m16_ms_42 Q: 2

(a)	1;	1
(b)	conducts electricity or heat / malleable / ductile / sonorous / shiny;	1
(c)	any two from: • (low) melting point / (low) boiling point; • hardness / softness / rubidium can be cut easily; • strength; • (low) density;	2

(d)(i)	any two from: • bubbles / effervescence / fizzing; • flame / sparks / ignites; • movement; • dissolves / forms a solution / disappears / gets smaller; • floats; • rubidium melts / rubidium forms a ball; • explosion;	2
(d)(ii)	yellow;	1
(d)(iii)	$2Rb + 2H_2O \rightarrow 2RbOH + H_2$ formula of RbOH; whole equation completely correct;	2
(d)(iv)	caesium → rubidium → potassium → sodium → lithium / Cs → Rb → K → Na → Li;	1
(d)(v)	goggles / glasses / gloves / safety screen / stand at safe distance / tongs / open space;	1
(e)	Rb_3PO_4;	1

12. 0620_m15_ms_32 Q: 6

(a) Any **two** from:
- bubbles / effervescence / fizzing
- (some of the) solid / copper carbonate dissolves / disappears **or** some (brown) solid seen (undissolved)
- (colourless) solution or liquid turns blue [2]

(b) filter / centrifuge / decant [1]

wash with (distilled) water [1]

(dry with) filter paper / tissues / warm windowsill / in sun / oven / fan / heat [1]

(c) (i) Blue precipitate / ppt [1]

(ii) $Cu^{2+} + 2OH^{-} \rightarrow Cu(OH)_2$ [1]

(d) (i) $Cu(OH)_2(s) \rightarrow CuO(s) + H_2O(g)$

Equation [1]

State symbols of correct chemical equation [1]

(ii) carbon / hydrogen [1]

[Total:10]

---

13. 0620_s15_ms_33 Q: 5

(a)	($CuCO_3$ →) $CuO + CO_2$; ($Cu(OH)_2$ →) $CuO + H_2O$; ($2Cu(NO_3)_2$ →) $2CuO + (4NO_2) + O_2$ species; balancing;	4	**A** multiples **I** state symbols
(b)(i)	(black to) pink / brown / orange;	1	**I** red
(b)(ii)	(hot) copper reacts / is oxidised; with oxygen / air;	2	**A** forms copper oxide for 2 marks
(b)(iii)	carbon monoxide / ammonia / methane;	1	
(b)(iv)	carbon / graphite or any metal more reactive than copper;	1	
(c)(i)	79.2828685; 79.6205853; 84.7161572;	2	Minimum 3 sig figs **A** rounding or truncating *All three correct = 2 marks,* *Two correct = 1 mark*
(c)(ii)	the last one **OR** Cu and O_2 **OR** the one from copper; not all the copper oxidised **OR** the outside of the pieces of copper oxidised but the inside did not **OR** (still) contains copper (metal);	2	ecf of biggest for M1

14. 0620_w15_ms_33 Q: 6

(a)	Na / sodium **and** Li / lithium;	**1**
(b)	Cu / copper **and** Rh / rhodium;	**1**
(c)	$Fe_2(SO_4)_3$;	**1**
(d)	Mg^{2+};	**1**
(e)	copper sulfate (solution); add manganese / Mn to solution; copper displaced or forms / blue colour changes; **or** (a solution of) an iron salt or a zinc salt; add copper and manganese to each; only manganese reacts / displaces; **or** (a solution of a) manganese salt and a copper salt; add, e.g. iron / zinc; copper (displaced) and manganese not; **or** to a (dilute) acid / any named acid / water / steam; add Mn and Cu / both metals to the liquid; rate faster or shorter time or more bubbles or more hydrogen or more gas with Mn or with the more reactive metal / reaction only with Mn or with the more reactive metal; **or** copper oxide; add manganese and heat; evidence of reaction; **or** burn manganese and copper / both elements; in air / oxygen; Mn or more reactive metal burns brighter / only Mn or more reactive metal burns / evidence that manganese reacts faster; **or** add carbon; to both metal oxides and heat; evidence that reaction occurs with copper oxide more readily / least reactive metal oxide;	**3**

	or both metal nitrates or carbonates; heat; evidence that manganese compound is most stable / most reactive compound is most stable; **or** (electrochemical) cell / use of voltmeter / electrolyte; copper and manganese (as electrodes); manganese is the negative terminal;	
(f)	*physical properties* any three from: hard; strong; high density; malleable; ductile; sonorous; shiny; high melting point / high boiling point; (good) conductor (of heat/electricity); forms coloured compounds / coloured ions / coloured salts; *chemical properties* any two: catalytic behaviour; more than one or different or variable oxidation state or oxidation number or valency / variable charges / many differently charged ions; forms complex (ions); forms coloured compounds / coloured ions / coloured salts; amphoteric oxide / amphoteric / basic oxide / alkaline oxides / acidic oxide; (other metallic reactions) with acids / water / steam; reducing agent / electron donor / reacts with non-metal to form ionic compound / forms positive ions;	**5**

15. 0620_s14_ms_31 Q: 6

(a) (i) rate at t_2 less than at t_1 **or** the rate decreases (1)

rate at t_3 zero / reaction stopped (1) [2]

(ii) rate at t_2 less than at t_1 because **concentration** of hydrogen peroxide is less at t_2 **or concentration** of hydrogen peroxide is decreasing. (1)

(rate at t_3 zero / reaction stopped because) hydrogen peroxide is used up (1) [2]

(b) (i) steeper and must come from the origin (1)
final volumes the same (1) [2]

(ii) Any **two** from: [2]
steeper curve because of a faster rate
faster rate because of increased surface area
same amount / volume / mass / no of mol of hydrogen peroxide
ecf for M1 for a shallower curve because of slower rate.

(c) filter (and rinse / wash) (1)

dry manganese (IV) oxide (1)

weigh / measure mass manganese(IV) oxide after reaction (1)

the mass should be 0.1 g **or** unchanged. (1) [4]

(d) number of moles of O_2 formed = 0.096 / 24 = 0.004 (1)
number of moles of H_2O_2 in 40 cm^3 of solution = $0.004 \times 2 = 0.008$ (1)

concentration of the hydrogen peroxide in mol / dm^3 = 0.008 / 0.04 = 0.2 (1) [3]

[Total:15]

16. 0620_s14_ms_31 Q: 7

(a) (i)

aqueous solution	lead Pb	magnesium Mg	zinc Zn	silver Ag
lead (II) nitrate		✓	✓	×
magnesium nitrate	××		×	×
zinc nitrate	×	✓		×
silver(I) nitrate	✓	✓	✓	

each horizontal line correct (1) [3]

(ii) Zn (1)

An arrow **from** Zn **to** Zn^{2+} (1) [2]

(iii) $Zn + 2Ag^{+} \rightarrow Zn^{2+} + 2Ag$ (1) [1]

(b) (i) correct direction from zinc to lead (1) [1]

(ii) metals react by **losing electrons** (1)

the more reactive metal/zinc will lose electrons more readily (making the electrode negatively charged). (1) [2]

(iii) manganese **and** zinc are more reactive than lead (and/or copper) (1)

lead is more reactive than copper (1) [2]

(iv) the **polarity** of a Mn/Zn (cell)
or the **voltages** of Zn/Pb **and** Mn/Pb (cells) (1) [1]

[Total: 12]

17. 0620_w14_ms_33 Q: 6

(a) Rb loses 1 electron/1 electron in outer shell/1 valency or valence electron [1]

Sr loses 2 electrons/2 electrons in outer shell/2 valency or valence electrons [1]

(b) (i) (mix solutions of) rubidium carbonate/Rb_2CO_3 [1]

strontium chloride/$SrCl_2$ **or** strontium nitrate/$Sr(NO_3)_2$ **or** strontium sulfate/$SrSO_4$ **or** strontium hydroxide/$Sr(OH)_2$ [1]

COND (on two correct reactants) filter **or** centrifuge **or** decant (the residue) [1]

wash <u>with water</u> **and** dry/press between filter paper/put in (low) oven/put on a (sunny) windowsill/put in sun/heat [1]

(ii) $SrCO_3 \rightarrow SrO + CO_2$ [1]

(c) (i) rubidium nitr**<u>ite</u>** or nitr**<u>ate(III)</u>** [1]

(ii) $2Sr(NO_3)_2 \rightarrow 2SrO + 4NO_2 + O_2$ [2]
Species (1) Balancing (1)

[Total: 10]

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18. 0620_s13_ms_31 Q: 5

(a) (i) any metal above zinc
$Mg \rightarrow Mg^{2+} + 2e^-$ [1]

(ii) $Zn + 2Ag^+ \rightarrow Zn^{2+} + 2Ag$ [2]
Note: not balanced only [1]

(iii) because they can accept or gain electrons / change into atoms or can be reduced [1]

(iv) Ag^+ or silver [1]
charge not essential but if given must be correct

(v) Ag^+ and Cu^{2+} **or** silver and copper [1]
charge not essential but if given must be correct

(b) Cu Sn Cd Zn *(i.e. all **4** in correct order)* [1]
relates order to voltage [1]

one relevant comment from: [1]

higher reactivity metals are the negative electrode / copper is least reactive because it is the positive electrode because copper would have the lowest voltage / copper cell V = 0 / the bigger the difference in reactivity, the bigger the voltage / zinc has highest voltage because it is most reactive / more reactive metals have higher voltage

[Total: 9]

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19. 0620_s13_ms_33 Q: 5

(a) (i) any Group 1 metal [1]
ACCEPT: lithium

(ii) $2Pb(NO_3)_2 \rightarrow 2\mathbf{PbO} + 4NO_2 + O_2$ [2]
PbO [1]
COND balancing [1]

(iii) the metal in **a (i)** is **more reactive** than lead [1]
more reactive metals have **more stable** compounds
OR has stronger (ionic) bonding [1]

(b) (i) speed / rate of forward reaction = speed / rate of back reaction [1]
OR macroscopic properties do not change / constant (with time)

(ii) goes darker **OR** goes brown [1]
COND lower pressure favours side with more moles [1]
COND this is NO_2 side **OR** reactant side **OR** goes left [1]

(iii) exothermic [1]

low temperatures favour the exothermic reaction **or**
low temperatures moves equilibrium to right / product side / towards N_2O_4 [1]

(iv) forward reaction is bond forming [1]

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20. 0620_w13_ms_31 Q: 2

(a) Any three of:
iron is harder
iron has higher density
ACCEPT: heavier **or** potassium lighter
iron has higher mp **or** bp
iron has higher tensile strength **or** stronger
iron has magnetic properties [3]
NOTE: has to be comparison, e.g. iron is hard (0) but iron is harder (1)
NOT: appearance e.g. shiny
ACCEPT: comparative statements relating to potassium

(b) potassium hydrogen (1) and potassium hydroxide (1)
zinc hydrogen (1) and zinc oxide (1)
copper no reaction (1) [5]

[Total: 8]

21. 0620_w13_ms_32 Q: 6

(a) (i) $Cu(OH)_2 \rightarrow CuO + H_2O$ [1]

(ii) Rb [1]

(b) (i) electron loss [1]

(ii) because they can accept electrons [1]

(c) (i) copper and mercury [1]

(ii) add copper / mercury / metal to (named) acid **and** no reaction / no bubbles / no hydrogen [1]

(d) (i) Mn [1]

(ii) (solution) becomes colourless / decolourises
NOT: clear [1]

[Total: 8]

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22. 0620_s12_ms_31 Q: 5

(a) calcium carbonate → calcium oxide + carbon dioxide [1]
accept: correct symbol equation

$Ca(OH)_2 \rightarrow CaO + H_2O$ [1]

(b) (i) CuO **and** NO_2 **and** O_2; [1]
accept: names or correct formulae

(ii) $2NaNO_3 \rightarrow 2NaNO_2 + O_2$ [2]
accept: $NaNO_3 \rightarrow NaNO_2 + 1/2\ O_2$
not balanced = [1]

(c) Na / Ca; [1]

(d) Cu; Ag; [2]
accept: *ions* Cu^{2+} *and* Ag^{+}

[Total: 8]
