IGCSE · Cambridge (CIE) · Chemistry

2 hours 17 questions

Theory Questions

Formulae & Relative Masses

Formulae / Empirical Formulae & Formulae of Ionic Compounds / Writing Equations / Ar & Mr

Easy (5 questions)	/30
Medium (7 questions)	/49
Hard (5 questions)	/41
Total Marks	**/120**

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Easy Questions

1 (a) When cobalt(II) oxide, CoO, is heated in air an oxide with the formula Co_3O_4 is formed.

Balance the equation for this reaction.

..... $CoO + O_2 \rightarrow 2Co_3O_4$

.....

(1 mark)

(b) Sulfuric acid is a compound.

The formula of sulfuric acid is H_2SO_4.

Complete **Table 1.1** to calculate the relative molecular mass of sulfuric acid.

Table 1.1

atom	number of atoms	relative atomic mass	
hydrogen	2	1	2 × 1 = 2
sulfur			
oxygen			

relative molecular mass = ...

.....

.....

(2 marks)

(c) Hydrogen is a fuel which can be obtained from water by electrolysis.

Refinery gas and petrol are fuels obtained by the fractional distillation of petroleum.

Complete the equation for the burning of hydrogen.

..... H_2 (g) + O_2 (g) → .....H_2O (l)

.....

(1 mark)

(d) State the meaning of (g) and (l).

(g):

(l):

.....

.....

(2 marks)

2 (a) In a blast furnace used for the extraction of iron, carbon reacts with oxygen from the air to form carbon monoxide.

Complete the chemical equation for this reaction.

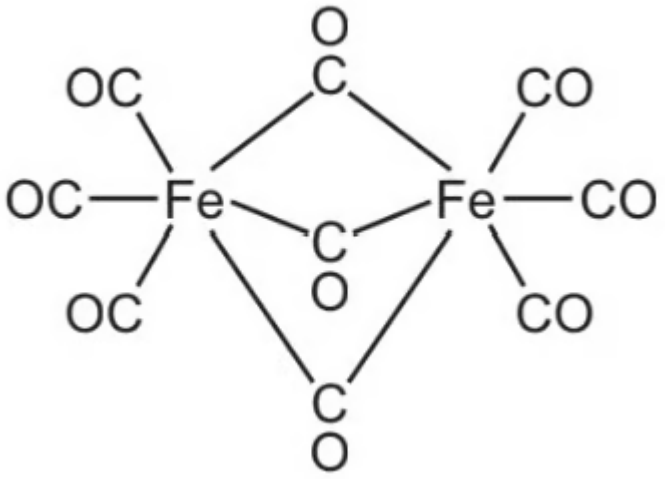
$$....C + ... \rightarrow 2CO$$

.....

.....

(2 marks)

(b) The structure of a compound of iron is shown.



Deduce the molecular formula of this compound to show the number of iron, carbon and oxygen atoms.

.....

(1 mark)

(c) Iodine reacts with aqueous sodium thiosulfate, $Na_2S_2O_3$.

Balance the chemical equation for this reaction.

$$.....Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + ...NaI$$

.....

(2 marks)

(d) Complete the table to calculate the relative formula mass of anhydrous copper(II) sulfate, $CuSO_4$.

Use your Periodic Table to help you.

type of atom	number of atoms	relative atomic mass	
copper	1	64	1 × 64 = 64
sulfur			
oxygen			

relative formula mass =_____

(2 marks)

3 (a) This question is about iron and compounds of iron.

Iron can be converted into steel in a basic oxygen converter.

Oxygen is blown into the impure molten iron to remove some of the impurities.

Oxygen reacts with the carbon in the impure iron to form carbon dioxide.

Write a chemical equation for this reaction.

.....

(1 mark)

(b) This question is about bromine and compounds of bromine.

Bromine reacts with hydrogen sulfide, H_2S.

Complete the chemical equation for this reaction.

..... + H_2S → .....HBr + S

.....

.....

(2 marks)

(c) This question is about cobalt and compounds of cobalt.

Complete the table to calculate the relative formula mass of anhydrous cobalt(II) sulfate, $CoSO_4$. Use your Periodic Table to help you.

type of atom	number of atoms	relative atomic mass	
cobalt			
sulfur	1	32	1 × 32 = 32
oxygen			

relative formula mass = _____

.....

.....

(2 marks)

4 (a) Extended Only

The names and formulae for some compounds are shown.

aluminium nitrate, $Al(NO_3)_3$ magnesium nitrate, $Mg(NO_3)_2$ sodium nitrate, $NaNO_3$

Deduce the formula for calcium nitrate.

.....

(1 mark)

(b) Sodium reacts with molten sodium hydroxide.

Complete the chemical equation for this reaction.

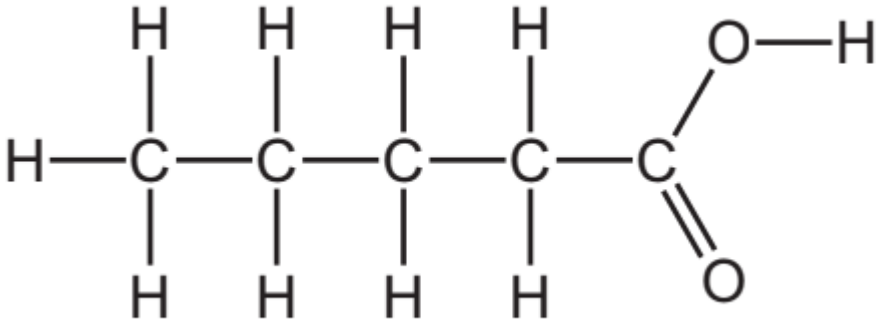
$$2Na + ...NaOH \rightarrow .....Na_2O + H_2$$

.....

.....

(2 marks)

(c) The structure of a carboxylic acid is shown.



Deduce the formula of this carboxylic acid to show the number of atoms of carbon, hydrogen and oxygen.

.....

(1 mark)

5 (a) This question is about reactions involving calcium compounds.

Heating calcium carbonate, $CaCO_3$, produces calcium oxide, CaO, and one other gaseous product.

Write the word equation for this reaction.

.....

.....

(2 marks)

(b) Extended Only

Write a balanced chemical equation for heating calcium carbonate, $CaCO_3$, to form calcium oxide, CaO, and one other gaseous product.

.....

(1 mark)

(c) Calcium hydroxide, $Ca(OH)_2$ can be made by the reaction of calcium oxide, CaO, with water.

$$CaO + H_2O \rightarrow Ca(OH)_2$$

112 g of calcium oxide reacts with 36 g of water.

Calculate the mass of calcium hydroxide that is produced.

_____ g

.....

(1 mark)

(d) Calcium hydroxide can be used to test for the presence of carbon dioxide.

If carbon dioxide is present, the calcium hydroxide will form a milky white precipitate of calcium carbonate.

The formula of calcium carbonate is $CaCO_3$

Calculate the relative formula mass (M_r) of calcium carbonate.

Relative atomic masses (A_r): C = 12 O = 16 Ca = 40

.....

.....

(2 marks)

(e) Calculate the percentage of oxygen in calcium carbonate, $CaCO_3$, using the following equation.

$$\text{Percentage by mass} = \frac{A_r \times \text{number of atoms}}{M_r \text{ of the compound}} \times 100$$

.....

.....

(2 marks)

Medium Questions

1 (a) Extended Only

Use your copy of the Periodic Table to help you answer these questions.

Predict the formula of each of the following compounds.

i) aluminium fluoride

[1]

ii) arsenic oxide

[1]

iii) silicon bromide

[1]

.....

.....

.....

(3 marks)

(b) Extended Only

Deduce the formula of each of the following ions.

i) phosphide

[1]

ii) barium

[1]

iii) francium

[1]

(3 marks)

(c) Extended Only

Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound carbon dioxide.

Use o to represent an electron from a carbon atom. Use x to represent an electron from an oxygen atom.

(3 marks)

2 (a) 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.

Complete the following equations.

i) $CuCO_3 \rightarrow$ ..... + ...

[1]

ii) $Cu(OH)_2 \rightarrow$ ..... + ...

[1]

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

[2]

.....

.....

.....

.....

(4 marks)

(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]

.....

.....

.....

.....

.....

(5 marks)

(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	
$Cu(NO3)_2$	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]

.....

.....

.....

.....

(4 marks)

3 (a) Extended Only

Iron pyrite, FeS_2, is known as Fool's Gold because it is a shiny yellow solid which is similar in appearance to gold. Iron pyrite is an ionic compound. Gold is a metallic element.

Iron pyrite, FeS_2, contains positive and negative ions. The positive ion is Fe^{2+}. Deduce the formula of the negative ion.

.....

(1 mark)

(b) A student is provided with a sample of iron pyrite and a sample of gold.

Suggest how the student could distinguish between the two substances.

.....

.....

(2 marks)

(c) Sulfur dioxide is produced on a large scale by heating iron pyrite strongly in air. The iron pyrite reacts with oxygen in the air producing iron(III) oxide, Fe_2O_3, and sulfur dioxide.

Construct a chemical equation for the reaction between iron pyrite and oxygen.

.....

.....

(2 marks)

4 (a) Extended Only

Element **X** can undergo the following physical changes.

Element **X** is a Group III metal. It burns in air to form an oxide X_2O_3.

Write a symbol equation for this reaction.

(2 marks)

(b) Extended Only

Aqueous silver nitrate is added to aqueous magnesium chloride. A white precipitate forms. Write an ionic equation for this reaction. Include state symbols.

(2 marks)

(c) Complete the chemical equation for the reaction of chlorine with phosphorus.

$$\ldots\ldots Cl_2 + 2P \rightarrow \ldots\ldots PCl_5$$

(2 marks)

(d) Aqueous potassium iodide reacts with aqueous copper(II) sulfate to produce iodine.

Balance the chemical equation for this reaction.

$$KI + CuSO_4 \rightarrow CuI + I_2 + K_2SO_4$$

(2 marks)

5 (a) This question is about elements X, Y and Z. An atom of element X is represented as $^{34}_{16}X$

What is the electronic structure of the ion X^{2-}?

.....

(1 mark)

(b) This question is about elements X, Y and Z.

Identify the atom against which the relative masses of all other atoms are compared.

.....

(1 mark)

(c) Extended Only

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

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

.....

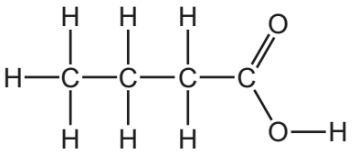
.....

(2 marks)

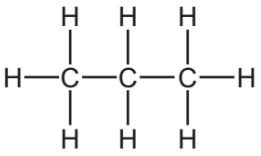
6 (a) Separate: Chemistry and Extended Only

The structures of five organic compounds, A, B, C, D and E, are shown. Answer the questions that follow. Each letter may be used once, more than once or not at all.

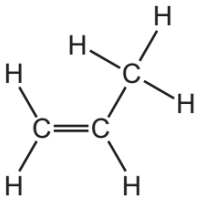
A



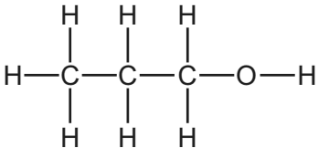
B



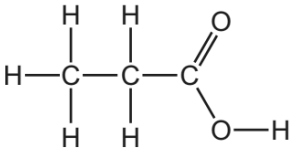
C



D



E



Give the letter of the compound that has the empirical formula CH_2.

.....

(1 mark)

(b) An endothermic reaction occurs when calcium nitrate is heated.

Balance the equation for this reaction.

$$.....Ca(NO_3)_2 \rightarrow .....CaO + ...NO_2 + ...O_2$$

.....

(1 mark)

7 (a) This question is about iron and iron compounds.

Iron reacts with chlorine to form iron(III) chloride, Fe_2Cl_6.

Balance the chemical equation for this reaction.

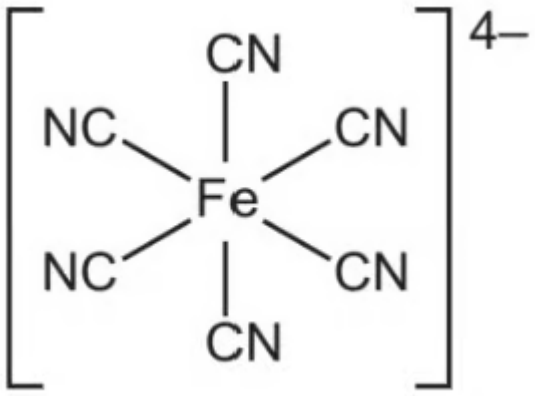
$$.....Fe + ...Cl_2 \rightarrow Fe_2Cl_6$$

.....

.....

(2 marks)

(b) The structure of an ion is shown.



Deduce the molecular formula of this ion to show the number of iron, carbon and nitrogen atoms.

.....

(1 mark)

(c) This question is about chlorine and compounds of chlorine.

Chlorine reacts with warm turpentine, $C_{10}H_{16}$.

Balance the chemical equation for this reaction.

$$C_{10}H_{16} + 8Cl_2 \rightarrow .....C + ...HCl$$

(2 marks)

(d) The equation shows the effect of heat on anhydrous zinc sulfate.

$$ZnSO_4 \xrightarrow{\text{heat}} ZnO + SO_3$$

When 12.60 g of anhydrous zinc sulfate is heated, the mass of zinc oxide formed is 6.34 g.

Calculate the mass of zinc oxide formed when 63.0 g of anhydrous zinc sulfate is heated.

mass of zinc oxide = _____

(1 mark)

(e) Complete the table to calculate the relative formula mass of anhydrous zinc sulfate, $ZnSO_4$. Use your Periodic Table to help you.

type of atom	number of atoms	relative atomic mass	
zinc	1	65	1 × 65 = 65
sulfur			
oxygen			

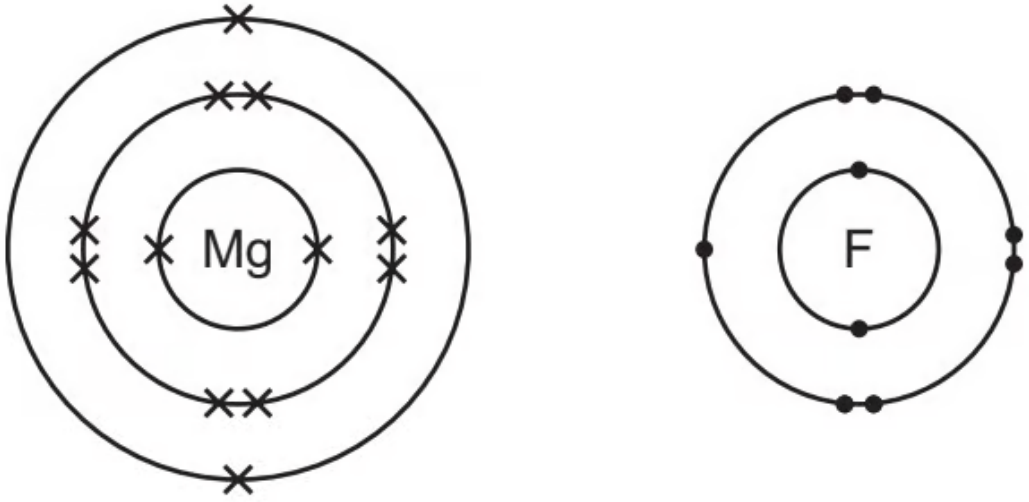
relative formula mass = _____

(2 marks)

Hard Questions

1 (a) Extended Only

Fluorine forms both ionic and covalent compounds. Magnesium reacts with fluorine to form the ionic compound magnesium fluoride. The electronic structures of an atom of magnesium and an atom of fluorine are shown.



What is the formula of magnesium fluoride?

.....

(1 mark)

(b) When copper is reacted with hot concentrated sulfuric acid, sulfur dioxide gas is formed.

Balance the chemical equation for this reaction.

$$Cu + ...H_2SO_4 \rightarrow CuSO_4 + SO_2 + ...H_2O$$

.....

.....

(2 marks)

(c) Extended Only

When sulfuric acid reacts with ammonia the salt produced is ammonium sulfate.

Write the chemical equation for this reaction.

.....

.....

(2 marks)

(d) Extended Only

Barium sulfate is an insoluble salt. Barium sulfate can be made from aqueous ammonium sulfate using a precipitation reaction.

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

.....

.....

(2 marks)

(e) Extended Only

Oxygen is produced by the decomposition of hydrogen peroxide. Manganese(IV) oxide is the catalyst for this reaction.

Oxygen can also be produced by the decomposition of potassium chlorate(V), $KClO_3$.

The only products of this decomposition are potassium chloride and oxygen.

Write a chemical equation for this decomposition.

.....

.....

(2 marks)

2 (a) Extended Only

This question is about titanium.

Titanium is a transition metal that is extracted from titanium dioxide in a two-stage industrial process.

In the first stage, titanium dioxide reacts with carbon and chlorine to form titanium tetrachloride and carbon monoxide.

Write the balanced symbol equation for this reaction.

(3 marks)

(b) Explain how your chemical symbol equation in part (a) demonstrates the law of conservation of mass.

(1 mark)

(c) Identify **two** hazards associated with Stage 1.

(2 marks)

(d) Separate: Chemistry and Extended Only

Calculate, to three significant figures, the percentage by mass of chlorine in titanium tetrachloride.

(A_r: Ti = 48 Cl = 35.5)

(2 marks)

3 (a) Extended Only

Magnesium displaces copper from copper sulfate solution.

Write the balanced symbol equation for the reaction.

You should include state symbols.

(2 marks)

(b) Extended Only

State **two** changes that would be observed during the displacement reaction.

(2 marks)

(c) Extended Only

Write the ionic equation for the displacement of copper from copper sulfate by magnesium. You should include state symbols.

(2 marks)

(d) Extended Only

Displacement reactions are examples of redox reactions.

Explain why the displacement reaction between magnesium and copper sulfate is both reduction and oxidation.

(2 marks)

4 (a) Extended Only

This question is about lead nitrate.

Lead nitrate is an ionic compound.

It consists of Pb^{2+} and NO_3^- ions.

What is the chemical formula of lead nitrate?

.....

(1 mark)

(b) Separate: Chemistry and Extended Only

Calculate the percentage by mass of oxygen in lead nitrate, $Pb(NO_3)_2$.

.....

.....

(2 marks)

(c) Extended Only

A displacement reaction occurs between solutions of lead nitrate and potassium iodide, KI, to form solid lead(II) iodide and aqueous potassium nitrate.

Write the balanced symbol equation, including state symbols, for this reaction.

.....

.....

.....

(3 marks)

(d) Separate: Chemistry Only

Table 1 summarises the solubility of a selection of ionic compounds in water.

Table 1

Soluble	Insoluble
All nitrates	
Most common chlorides	Silver chloride, lead chloride
Most common sulfates	Lead sulfate, barium sulfate, calcium sulfate
Sodium carbonate, potassium carbonate, ammonium carbonate	Most common carbonates

The displacement reaction between lead nitrate and potassium iodide forms a yellow precipitate.

Justify which chemical is responsible for the yellow colour.

.....

.....

(2 marks)

5 (a) The relative atomic mass, A_r, for each element is shown in the Periodic Table.

Define the term relative atomic mass.

(2 marks)

(b) Separate: Chemistry and Extended Only

The element gallium has a relative atomic mass of 69.735 and only contains two isotopes. A sample of gallium contained the isotope ^{69}Ga, with a relative abundance of 63.25 %. Calculate the mass number of the other isotope. You **must** show all your working.

(2 marks)

(c) Extended Only

Define the term empirical formula.

(1 mark)

(d) Separate: Chemistry and Extended Only

An unknown compound contains carbon, hydrogen and oxygen.

It consists of 18% carbon,and 73 % oxygen.

Calculate the empirical formula of the unknown compound

(3 marks)