C3: Quantitative Chemistry

ANSWER KEY

8.1	What is the law of conservation of mass?	Total mass of reactants = total mass of products
8.2	When magnesium reacts with oxygen to form magnesium oxide, why does the mass increase?	Oxygen atoms have been joined to the magnesium (that had not been weighed beforehand as they came from the air)
8.3	When calcium carbonate reacts with acid and makes carbon dioxide, why does the mass decrease?	Because carbon dioxide is a gas and escapes from the reaction
8.4	What is relative formula mass, Mr?	The sum of the masses of each atom in a compound
8.5	What are the four state symbols and what do they stand for?	(s) solid (l) liquid (g) gas (aq) aqueous - dissolved in water
8.6	What does excess mean?	We have some of this substance left over, unreacted, after the reaction (we had more than we needed)
8.7	(HT) What is a limiting reactant?	A substance that is completely used up, or reacted, in a reaction
8.8	What is the unit for concentration?	g/dm³
8.9	Which formula relates concentration, mass and volume?	Concentration = <u>mass (in g)</u> volume (in dm³)
8.10	What is the correct rearrangement of this formula to calculate mass?	Mass (in g) = concentration x volume (in dm ³)
8.11	How many cm ³ are there in 1 dm ³ ?	1 dm³ = 1000 cm³
8.12	How do we convert 25 cm ³ into dm ³ ?	25 cm ³ = 0.025 dm ³ (divide by 1000)
8.13	(HT) What is Avogadro's number?	6.02 x 10 ²³
8.14	(HT) What formula relates moles, mass and Mr?	Moles = <u>mass</u> Mr
8.15	(HT) What is the correct rearrangement of this formula to calculate mass?	Mass = moles x Mr
8.16	How many mg is 0.34 g?	1 g = 1000 mg so 0.34 g = 340 mg (x1000)
8.17	How many g is 0.75 kg?	1 kg = 1000 g so 0.75 kg = 750 g (x1000)

C3: Simple Numerical Questions

ANSWER KEY

1	How many different elements are present in the formula H ₂ SO ₄ ?	3 (count the capital letters) H = hydrogen, S = sulfur, O = oxygen
2	How many different atoms are present in the formula H ₂ SO ₄ ?	7 (2 x H, 1 x S and 4 x O = 7)
3	What is the formula of sodium oxide, made from Na⁺ and O²- ions?	Na ₂ O
4	What is the formula of aluminium chloride, made from Al ³⁺ and Cl ⁻ ions?	AICI3
5	iron + oxygen → iron oxide ^{112 g} 48 g ? If 112 g of iron reacts with 48 g of oxygen, how much iron oxide should be formed?	112 + 48 = 160 g Total mass of reactants = total mass of products
6	nitrogen + hydrogen → ammonia	34 - 28 = 6 g
	34 g of ammonia is made from 28 g of nitrogen. How much hydrogen gas must have reacted?	Total mass of reactants = total mass of products
7	Balance the following equations:	Must have same number of atoms on each side
	a)_Ca +O₂ →_CaO	a) 2 Ca + $O_2 \rightarrow 2$ CaO
	b) AI + Br ₂ \rightarrow AlBr ₃	b) 2 Al + 3 Br ₂ \rightarrow 2 AlBr ₃
	c) K + O ₂ \rightarrow K ₂ O	c) 4 K + O ₂ \rightarrow 2 K ₂ O
	d) C_5H_{12} + $O_2 \rightarrow CO_2$ + H_2O	d) C_5H_{12} + 8 $O_2 \rightarrow 5 CO_2$ + 6 H_2O
8	Use your periodic table to calculate the formula mass, Mr, of:	a) $CO_2 = (1 \times C) + (2 \times O) = 12 + (2 \times 16) = 44$ b) $H_2SO_4 = (2 \times H) + (1 \times S) + (4 \times O)$
	a) CO ₂	$= (2 \times 1) + 32 + (4 \times 16) = 98$
	b) H ₂ SO ₄ c) Mg(NO ₃) ₂	c) $Mg(NO_3)_2 = (1 \times Mg) + (2 \times N) + (6 \times O)$ = 24 + (2 x 14) + (6 x 16) = 148
9	A solution has a concentration of 12 g/dm ³ . Calculate the mass of solid dissolved in 25 cm ³ of this solution?	25 cm ³ = 0.025 dm ³ (divide by 1000) Mass = concentration x volume = 12 x 0.025 = 0.3 g
10	0.35 g of solid is dissolved in 20 cm ³ of water. Calculate the concentration of the solution in g/dm ³	20 cm ³ = 0.02 dm ³ (divide by 1000) Concentration = mass/volume = 0.35/0.02 = 17.5 g/dm ³

FOUNDATION TIER

Q1. This question is about Group 1 metals.

The graph below shows the melting points of Group 1 metals plotted against their atomic number.



(b) Determine the atomic number and melting point of caesium. Use the graph above.

Atomic number of caesium = _____ °C

Lithium is a Group 1 metal.

(c) A lithium atom can be shown as 3

How many electrons does the outer shell of a lithium atom contain?

(1)

(1)

(d) Lithium reacts with oxygen to produce lithium oxide.

Draw **one** line from each substance to the correct description of the substance.



(2)

(e) Balance the equation for the reaction of lithium with oxygen.

$$__Li + O_2 \rightarrow 2Li_2O$$

(1)

(1)

(f) What type of bonding is present in lithium oxide?

Tick one box.

Covalent	
lonic	
Metallic	

(g) Calculate the relative formula mass (M_r) of lithium oxide (Li₂O).

Relative atomic masses (A_r): Li = 7 O = 16

Relative formula mass =

(2) (Total 9 marks) The law of conservation of mass states that the mass of the products is equal to the mass of the reactants. This is the method used.

- 1. Pour lead nitrate solution into a beaker labelled A.
- 2. Pour potassium chromate solution into a beaker labelled **B**.
- 3. Measure the mass of both beakers and contents.
- 4. Pour the solution from beaker **B** into beaker **A**.
- 5. Measure the mass of both beakers and contents again.

When lead nitrate solution and potassium chromate solution are mixed, a reaction takes place.

This is the equation for the reaction:

 $Pb(NO_3)_2(aq) + K_2CrO_4(aq) \rightarrow PbCrO_4(s) + 2KNO_3(aq)$

(a) What would the student see when the reaction takes place?

(1)

(b) The table shows the student's results.

	Mass in g
Beaker A and contents before mixing	128.71
Beaker B and contents before mixing	128.97
Beaker A and contents after mixing	154.10
Beaker B after mixing	103.58

Show that the law of conservation of mass is true.

Use the data from the table above.

(2)

(c) What is the resolution of the balance used to obtain the results in the table?

Tick (\checkmark) one box.



	Relative formula mass =
The s	solution of lead nitrate has a concentration of 6 g/dm ³
Calcu	ulate the mass of lead nitrate that is dissolved in 25 cm ³ of this solution
	dissolved mass =
Anoth	her student also tests the law of conservation of mass using the same metho
The s	student uses a different reaction.
This i	is the equation for the reaction.
	$Na_2CO_3(aq) + 2HCI(aq) \rightarrow 2NaCI(aq) + CO_2(g) + H_2O(I)$
Expla conse	ain why this student's results would not appear to support the law of ervation of mass.

HIGHER TIER

- **Q3.** This question is about gold and compounds of gold.
 - (a) In the alpha particle scattering experiment alpha particles are fired at gold foil.Alpha particles are positively charged. The diagram below shows the results.



What **two** conclusions can be made from the results? Tick (\checkmark) **two** boxes.

Atoms are balls of positive charge with embedded electrons.

Atoms are tiny spheres that cannot be divided.

Atoms have a positively charged nucleus.

Mass is concentrated in the nucleus in the centre of atoms.

Neutrons exist within the nucleus.

- (b) The gold foil is:
 - 4.00×10^{-7} metres thick
 - 2400 atoms thick.

What is the diameter of one gold atom in metres? Give your answer to 3 significant figures.

Diameter of one gold atom (3 significant figures) = _____

m

(2)

(c) Gold reacts with the elements in Group 7 of the periodic table.

0.175 g of gold reacts with chlorine.

The equation for the reaction is:

$$2 \text{ Au} + 3 \text{ Cl}_2 \rightarrow 2 \text{ AuCl}_3$$

Calculate the mass of chlorine needed to react with 0.175 g of gold.

Give your answer in mg. Relative atomic masses (A_r): CI = 35.5 Au = 197

Mass of chlorine = mg
0
Tatal 40 manual
LINTAL 111 MARK

- **Q4.** This question is about fluorine.
 - (a) Calcium reacts with fluorine to produce calcium fluoride (CaF₂).

Explain how oxidation and reduction have taken place in this reaction.

Write about electron transfer in your answer.

(b) Explain why calcium fluoride has a high melting point.

(4)

(c) Fluorine reacts with sulfur to produce sulfur hexafluoride (SF₆).

$$S + 3F_2 \rightarrow SF_6$$

Relative formula masses, M_r : $F_2 = 38$ $SF_6 = 146$

Calculate the mass of sulfur hexafluoride produced when 0.950 g of fluorine is reacted with an excess of sulfur.

Give your answer to 3 significant figures.

g	Mass =	
(Total 13 mark		

Mark schemes

Q1.

QI.		
(a)	melting points decrease (as the atomic number increases) allow negative correlation	1
(b)	55 and 29 (°C) <i>allow values in range 28–32 (°C)</i>	
(-)	4	1
(C)		1
(d)	Substance Description	
	Lithium axide element Oxygen mixture	
	poly mon	1 1
(e)	4 Li + $O_2 \rightarrow 2$ Li ₂ O allow correct multiples	1
(f)	ionic	1
(g)	$(M_r) = (2 \times 7) + 16$	1
	= 30	1
	an answer of 30 scores 2 marks	1
Q2. (a)	precipitate / solid formed allow colour change	1
(h)	total mass before = 257.69 a	

[9]

1

(b) total mass before = 257.68 g total mass after = 257.68 g

1

(c)	0.01 g	1
(d)	207 + (2 × 14) + (6 × 16) or	
	207 + 2 × [14 + (3 × 16)]	1
	= 331	1
	an answer of 331 scores 2 marks	
(e)	$\frac{25}{1000}$ = 0.025 dm ³	
	0.025 x 6 g = 0.15 (g)	1
(f)	carbon dioxide is formed allow a gas is produced	1
	the gas escapes during the reaction	1
	(so) the mass at the end is less than expected	1 [11]
Q3.		
(a)	atoms have a positively charged nucleus.	1
	mass is concentrated in the nucleus in the centre of atoms.	1
(b)	<u>4 × 10⁻⁷</u> 2400	1
	$= 1.66666 \times 10^{-10}$	1
	= 1.67 × 10 ⁻¹⁰ (m) allow 0.000 000 000 167 (m) allow an answer correctly rounded to 3 significant figures from an incorrect calculation which uses	
	the values in the question	1

(c) moles Au = $\frac{0.175}{197}$ = 0.000888

		1
moles Cl₂	$= 0.000888 \times \frac{3}{2} = 0.00133$ allow a correct calculation using an incorrectly calculated value of moles of gold	1
mass Cl ₂ =	= 0.00133 × 71 allow a correct calculation using an incorrectly calculated value of moles of chlorine	1
= 0.0946 ((g)	1
= 94.6 (mg	g) allow a correct conversion using an incorrectly calculated mass of chlorine	1
alternativ	e approach:	
(from equa (so) 394 g	ation 2 moles of Au reacts with 3 moles of Cl_2) Au reacts with 213 g Cl_2 (1)	
1 g Au rea 0.54 g Cl₂	acts with ($\frac{213}{394}$ =) (1) allow a correct calculation using an incorrectly calculated value of mass of gold and / or chlorine	
0.175 g Aı 0.54 × 0.1	u reacts with 75 g Cl ₂ (1) <i>allow a correct calculation using an incorrectly</i> <i>calculated value of mass of gold and / or chlorine</i>	
= 0.0946 ((g) (1)	
= 94.6 (mg	g) (1) allow a correct conversion using an incorrectly calculated mass of chlorine	

[10]

Q4. (a)		
	Level 2: Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.	3-4
	Level 1: Points are identified and stated simply, but their relevance is not clear and	1-2

there is no attempt at logical linking.	
No relevant content	0
Indicative content	
Ca / calcium (atom) loses two electrons / both outer electrons and is oxidised to Ca ²⁺ ion	
F / fluorine (atom) gain one / an electron and is reduced to F ⁻ ion	
supporting points	
 fluorine / F (atoms) gain electron(s) 	
negative ion produced	
 calcium (atoms) lose electron(s) 	
positive ion produced	
 reduction is gain of electrons 	
oxidation is loss of electrons	
onic bonding between Ca²+ and F ⁻ ions / oppositely charged i in a) giant structure / lattice	ons
so a lot of energy is needed to overcome / brea	k this attraction
moles of $F_2 = \frac{0.95}{38} = 0.025$ moles mark is for ÷ 38	
moles of SF ₆ = $\frac{1}{3} \times 0.25 = 0.008333$ moles mark is for ×1/3	
mass of $SF_6 = 0.008333 \times 146$	

(b)

(c)

mass = 1.2166666

mass = 1.22 (g) 3 sig figs