Write your name, centre number and candidate number in the boxes below.

Surname	Other names

Centre number | | | | | |

Candidate number | | | | |

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Mole calculations

Time allowed: 45 minutes

Subject code **0620**

Chemistry

Paper 4 (Extended)

You must have: a ruler marked in centimetres and millimetres, a protractor, compasses, a pen, an HB pencil and an eraser.

Total marks

/ 46

Instructions

- Answer every question in the space provided on this paper.
- Write in black or dark blue ink. Pencil may be used for diagrams and graphs.
- Fill in your name, centre number and candidate number above.
- Show your working: a correct method can earn marks even if the answer is wrong.

Information

- This paper has 6 questions worth 46 marks in total.
- The marks for each question or part are shown in brackets, for example [3].

Advice

- Read every question through once before you write anything.
- Use the marks in brackets to judge how long to spend on each part.
- If you finish early, go back and check your working.

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Print at 100% (Actual size) so diagrams keep their real measurements.

1 Nitrates such as ammonium nitrate are used as fertilisers.

The final stage in the production of ammonium nitrate is shown in the equation.

$$Ca(NO_3)_2 + 2NH_3 + CO_2 + H_2O \rightarrow 2NH_4NO_3 + CaCO_3$$

Calculate the maximum mass of ammonium nitrate that can be produced from 820 g of calcium nitrate, $Ca(NO_3)_2$, using the following steps.

The relative formula mass, M_r, of calcium nitrate, $Ca(NO_3)_2$, = 164.

- Calculate the number of moles of $Ca(NO_3)_2$ in 820 g.

..... mol

- Deduce the number of moles of NH_4NO_3 produced.

..... mol

- Calculate the M_r of NH_4NO_3.

M_r of NH_4NO_3 = ...

- Calculate the maximum mass of ammonium nitrate produced.

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..... g
[4]

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Reduced to 78% to fit the page (wider than A4).

1	**M1** 5 moles of calcium nitrate (1) **M2** 10 moles ammonium nitrate (1) or ecf **M1** × 2 **M 3** M_r of ammonium nitrate = 80 **M4** 800 g or ecf **M2** × **M3**	**4**

2 Calcium chloride can be made by reacting calcium carbonate with hydrochloric acid.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

An excess of calcium carbonate was added to 50.0 cm^3 of 0.500 mol/dm^3 hydrochloric acid. The solution was filtered to remove the excess calcium carbonate.

(a) How many moles of HCl were used in this reaction?

..... mol [2]

(b) Deduce the number of moles of carbon dioxide gas made in this reaction.

..... mol [1]

(c) Calculate the mass of carbon dioxide made in this reaction.

..... g [2]

(d) Calculate the volume, in dm^3, of carbon dioxide made in this reaction at room temperature and pressure (r.t.p.).

..... dm^3 [1]

[Total: 6]

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2(a)	0.025 **M1** 50 / 1000 (=0.05) **M2** (0.05 × 0.5) = 0.025	 **1** **1**
2(b)	0.0125	**1**
2(c)	0.55 **M1** 44 **M2** 0.55	 **1** **1**
2(d)	0.3	**1**

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3 Sodium hydrogencarbonate is found in baking powder.

When sodium hydrogencarbonate is heated it forms three products.

$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

(a) Name the type of reaction that takes place when sodium hydrogencarbonate reacts in this way.

..... [1]

(b) Calculate the volume of carbon dioxide formed at room temperature and pressure when 12.6 g of $NaHCO_3$ is heated using the following steps:

- determine the mass of one mole of $NaHCO_3$

..... g

- calculate the number of moles of $NaHCO_3$ used

..... moles

- determine the number of moles of carbon dioxide formed

..... moles

- calculate the volume of carbon dioxide formed at room temperature and pressure.

..... dm^3
[4]

(c) Limewater is aqueous calcium hydroxide. Carbon dioxide turns limewater milky because a white precipitate forms.

Write the formula of:

- calcium hydroxide .....
- the white precipitate that forms when limewater turns milky. .....
[2]

[Total: 7]

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3(a)	(thermal) decomposition	1
3(b)	84 (1) 12.6 / 84 = 0.15(00) (1) 0.15(00) / 2 = 0.075(00) (1) 0.075(0) × 24.0 = 1.8 (1)	4
3(c)	$Ca(OH)_2$ (1) $CaCO_3$ (1)	2

4 **(a)** Define the following

(i) the mole

.....

..... [1]

(ii) the Avogadro constant

.....

..... [1]

(b) Which **two** of the following contain the same number of molecules?
Show how you arrived at your answer.

2.0 g of methane, CH_4

8.0 g of oxygen, O_2

2.0 g of ozone, O_3

8.0 g of sulfur dioxide, SO_2

.....

.....

..... [2]

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(c) 4.8 g of calcium is added to 3.6 g of water. The following reaction occurs.

$$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$$

(i) the number of moles of Ca = ...

the number of moles of H_2O = ... [1]

(ii) Which reagent is in excess? Explain your choice.

.....

..... [2]

(iii) Calculate the mass of the reagent named in **(ii)** which remained at the end of the experiment.

.....

..... [1]

[Total: 8]

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4 **(a)** **(i)** (the number of particles which is equal to the number of atoms in) 12 g of carbon 12
or
the mass in grams which contains the Avogadro's constant number of particles
or
Avogadro's constant **or** 6 to 6.023 × 10^{23} of atoms / ions / molecules / electrons / particles
or
(the amount of substance which has a mass equal to) its relative formula mass / relative atomic mass / relative molecular mass in grams
or
(the amount of substance which has a volume equal to) 24 dm^3 of a gas at RTP
[1]

(ii) (Avogadro's constant is the) number of particles / atoms / ions / molecules in one mole of a substance
or
the number of carbon atoms in 12 g of C(12).
or
the number of particles / molecules in 24 dm^3 of a gas at RTP
or
6 to 6.023 × 10^{23} (particles / atoms / ions / molecules / electrons) [1]

(b) CH_4 **and** SO_2 [1]

2/16 = 1/8 or 0.125 moles of CH_4 **AND** 8/64 = 1/8 or 0.125 moles of SO_2 [1]

(c) **(i)** 4.8/40 = 0.12 moles of Ca
3.6/18 = 0.2 moles of H_2O **both** correct [1]

(ii) Ca is in excess (**no mark**) (because 0.12 moles of Ca need) 0.24 moles / 4.32 g of H_2O to react [1]
there is not enough / there are 0.2 moles / 3.6 g of H_2O [1]
or
Ca is in excess **(no mark)** (because 0.2 moles / 3.6 g of water will react with) 0.1moles/4.0 g of Ca [1]
there is more than that / there are 0.12 moles / 4.8 g of Ca [1]
or
Ca is in excess **(no mark)** because the mole ratio Ca:H_2O is 3:5 / mass ratio 4:3 [1]
which is bigger than the required mole ratio of 1:2 / mass ratio 10:9 [1]
or
Ca is in excess **(no mark)** because the mole ratio H_2O:Ca is 5:3 / mass ratio 3:4 [1]
which is smaller than the required mole ratio of 2:1 / mass ratio 9:10 [1]

(iii) 0.02 × 40 = 0.8 (g) [1]

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5 Dilute hydrochloric acid reacts with sodium carbonate solution.

$$2HCl(aq) + Na_2CO_3(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$$

(a) Explain why effervescence is seen during the reaction.

.....

..... [1]

(b) Dilute hydrochloric acid was titrated with sodium carbonate solution.

- 10.0 cm^3 of 0.100 mol/dm^3 hydrochloric acid were placed in a conical flask.
- A few drops of methyl orange indicator were added to the dilute hydrochloric acid.
- The mixture was titrated with sodium carbonate solution.
- 16.2 cm^3 of sodium carbonate solution were required to react completely with the acid.

(i) What colour would the methyl orange indicator be in the hydrochloric acid?

..... [1]

(ii) Calculate how many moles of hydrochloric acid were used.

..... mol [1]

(iii) Use your answer to **(b)(ii)** and the equation for the reaction to calculate the number of moles of sodium carbonate that reacted.

..... mol [1]

(iv) Use your answer to **(b)(iii)** to calculate the concentration of the sodium carbonate solution in mol/dm^3.

..... mol/dm^3 [2]

(c) In another experiment, 0.020 mol of sodium carbonate were reacted with excess hydrochloric acid.

Calculate the maximum volume (at r.t.p.) of carbon dioxide gas that could be made in this reaction.

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..... dm^3 [3]

[Total: 9]

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5(a)	carbon dioxide / a gas is made;	**1**
5(b)(i)	red;	**1**
5(b)(ii)	0.001;	**1**
5(b)(iii)	0.0005;	**1**
5(b)(iv)	0.031 (2 marks) **M1 (iii)** / 0.0162;	**2**
5(c)	0.48 (dm^3) **M1** moles carbon dioxide = 0.02; **M2** volume carbon dioxide = 0.02 × 24; **M3** = 0.48 (dm^3);	**3** 1 1 1

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6 This question is about masses, volumes and moles.

(a) Which term is defined by the following statement?

The average mass of naturally occurring atoms of an element on a scale where the ^{12}C atom has a mass of exactly 12 units.

..... [1]

(b) Butane, C_4H_{10}, has a relative **molecular** mass of 58.
Potassium fluoride, KF, has a relative **formula** mass of 58.

Explain why the term relative molecular mass can be used for butane but **cannot** be used for potassium fluoride.

.....

..... [2]

(c) A 0.095 g sample of gaseous element **Y** occupies 60.0 cm^3 at room temperature and pressure.

- Determine the number of moles of element **Y** in 60.0 cm^3.

moles of element **Y** = ... mol

- Calculate the relative molecular mass of element **Y** and hence suggest the identity of element **Y**.

relative molecular mass = ...

identity of element **Y** = ...
[3]

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(d) A 1.68 g sample of phosphorus was burned and formed 3.87 g of an oxide of phosphorus.

Calculate the empirical formula of this oxide of phosphorus.

empirical formula = ... [4]

(e) Another oxide of phosphorus has the empirical formula P_2O_3.
One molecule of this oxide of phosphorus contains four atoms of phosphorus.

Calculate the mass of **one** mole of this oxide of phosphorus.

mass = ... g [2]

[Total: 12]

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6(a)	relative atomic mass	**1**
6(b)	C_4H_{10} is covalent	**1**
	KF is ionic	**1**
6(c)	mol of **Y** = 0.060 / 24.0 = 2.5×10^{-3} or 0.0025	**1**
	M_r = 0.095 / 2.5×10^{-3} = 38(.0)	**1**
	fluorine	**1**
6(d)	mass of O = 3.87 g – 1.68 g = 2.19 (g)	**1**
	mol of P 1.68 / 31 OR 0.054.. and mol of O 2.19 / 16 **OR** 0.13…	**1**
	ratio of P to O P = 0.054… / 0.054 = 1 O = 0.13… / 0.054… = 2.5	**1**
	whole number ratio and P_2O_5 = 2 = 5	**1**
6(e)	the formula is P_4O_6 or (one mole of) P_2O_3 = 110 (g)	**1**
	mass = 220 (g)	**1**

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