Past-paper walk-through

The mole and the Avogadro constant ▪ 3.3

eXercise

Questions in this set

- 0620/21 N25 Q10 ▪ 1 mark
- 0620/21 N25 Q11 ▪ 1 mark
- 0620/22 N25 Q10 ▪ 1 mark
- 0620/23 N25 Q12 ▪ 1 mark
- 0620/41 N25 Q3 ▪ 14 marks
- 0620/42 N25 Q3 ▪ 13 marks
- 0620/21 J25 Q9 ▪ 1 mark
- 0620/21 J25 Q20 ▪ 1 mark
- 0620/22 J25 Q9 ▪ 1 mark
- 0620/22 M25 Q12 ▪ 1 mark

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 10

0620/21 N25 ▪ Q10 ▪ 1 mark

10 The equation for the reaction between copper(II) oxide, CuO, and ammonia is given.

$$3CuO + 2NH_3 \rightarrow 3Cu + 3H_2O + N_2$$

[M_r: CuO, 80; NH_3, 17; H_2O, 18; N_2, 28]

[A_r: Cu, 64]

Which statements about this reaction are correct?

1 80.0 g of copper(II) oxide reacts exactly with 17.0 g of ammonia.

2 4.0 g of copper(II) oxide reacts with excess ammonia to produce 3.2 g of copper.

Question 10

3 The mass of water produced in this reaction is greater than the mass of nitrogen.

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

Solution 10

Answer: **D**

Why

- Use the equation's ratios: 3 mol CuO reacts with 2 mol NH_3 to give 3 mol Cu and 1 mol N_2.
- Convert masses to moles with the M_r values given before comparing anything.
- Copper is reduced from $+2$ to 0, so the ammonia is the reducing agent.

Question 11

0620/21 N25 ▪ Q11 ▪ 1 mark

11 How many atoms are present in 1.00 mol of argon?

A 2.06×10^{23} **B** 3.02×10^{26} **C** 6.02×10^{23} **D** 6.32×10^{20}

Solution 11

Answer: **C**

Why

- One mole of any substance contains the Avogadro number of particles.
- Argon is monatomic, so one mole of argon is one mole of *atoms*.
- That is 6.02×10^{23}.

Question 10

0620/22 N25 ▪ Q10 ▪ 1 mark

10 The equation for the combustion of ethanol is shown.

$$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

The relative molecular mass, M_r, of ethanol is 46.

Which statement about the reaction is correct?

A 4.6 g of ethanol produces 4.4 g of carbon dioxide.

B 92 g of ethanol produces 88 g of carbon dioxide and 108 g of water.

Question 10

C 138 g of ethanol reacts with 32 g of oxygen.

D 184 g of ethanol produces 216 g of water.

Solution 10

Answer: **D**

Why

- Work in moles: $M_r = 46$, so 4.6 g of ethanol is 0.10 mol.
- The equation gives 2 mol of CO_2 per mol of ethanol, so 0.20 mol $= 8.8$ g.
- Always go mass $\rightarrow$ moles $\rightarrow$ ratio $\rightarrow$ moles $\rightarrow$ mass; comparing masses directly is the trap.

Question 12

0620/23 N25 ▪ Q12 ▪ 1 mark

12 Calcium carbonate decomposes when heated strongly.

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

How many gaseous molecules are produced when 10.0 g of calcium carbonate is completely decomposed?

A 1.00×10^{22} **B** 1.20×10^{23} **C** 6.02×10^{22} **D** 6.02×10^{23}

Solution 12

Answer: **C**

Why

- M_r of $CaCO_3 = 40 + 12 + 48 = 100$, so 10.0 g is 0.100 mol.
- The equation gives one CO_2 per $CaCO_3$, so 0.100 mol of gas.
- $0.100 \times 6.02 \times 10^{23} = 6.02 \times 10^{22}$ molecules.

Question 3

0620/41 N25 ▪ Q3 ▪ 14 marks

3 A student makes crystals of the salt sodium sulfate, Na_2SO_4. The student reacts $0.200\,mol/dm^3$ dilute sulfuric acid, $H_2SO_4(aq)$, with aqueous sodium hydroxide, NaOH(aq).

The student uses the following steps.

step 1 The student places $40.0\,cm^3$ of NaOH(aq) into a conical flask. This volume contains 0.0100 moles of NaOH.

step 2 The student adds a few drops of methyl orange indicator to the NaOH(aq) in the conical flask.

step 3 The student adds $0.200\,mol/dm^3$ $H_2SO_4(aq)$ to the flask until the end-point is reached.

step 4 The student transfers the mixture from the conical flask to an evaporating basin and obtains dry crystals.

(a) Complete the symbol equation for the reaction. Include state symbols.

Question 3

Question 3

[2]

(b) State the type of exothermic reaction taking place.

Question 3

(c) Calculate the concentration of NaOH(aq) used in **step 1**.

Question 3

(d) Name the item of apparatus the student uses to add $H_2SO_4(aq)$ in **step 3**.

Question 3

(e) Calculate the volume of $H_2SO_4(aq)$, in cm^3, added in **step 3**.

Question 3

(f) State the colour change observed in **step 3**.

Question 3

(g) The dry crystals formed in **step 4** are coloured and **not** white. This is because the student should do an additional step between **step 3** and **step 4**.

Suggest what the student should do in this additional step to produce white crystals.

Question 3

(h) In **step 4**, the student gently heats the solution in the evaporating basin until the solution is saturated. The student then stops heating and leaves the hot solution to cool. Crystals start to appear.

(i) Explain the term saturated solution.

Question 3

(ii) Explain why crystals start to appear as the hot solution cools.

Question 3

(iii) Suggest the effect, if any, on the mass of crystals collected in **step 4** if the solution in the evaporating basin is allowed to dry without gentle heating.

Question 3

[Total: 14]

Solution 3

(a)

Mark scheme

- M1 2H2O M2
- state symbols (aq) and (l)
- 2

Solution 3

(b)

Mark scheme

- neutralisation
- 1

Solution 3

(c)

Mark scheme

- $0.0100 \times 1000 \div 40 = 0.25(0)$
- 1

Solution 3

(d)

Mark scheme

- burette
- 1

Solution 3

(e)

Mark scheme

- M1 mol H2SO4 needed $= 0.0100 \div 2 = 0.005(00)$ M2
- vol of H2SO4 needed $= 0.005(00) \div 0.200 \times 1000 = 25$ (cm3)
- 2

Solution 3

(f)

Mark scheme

- M1 yellow M2
- orange
- 2

Solution 3

(g)

Mark scheme

- repeat steps 1 and 3 without indicator
- 1

Solution 3

(h)(i)

Mark scheme

- M1 (a solution containing the) maximum concentration of a solute dissolved in the solvent M2
- at a specified temperature
- 2

Solution 3

(h)(ii)

Mark scheme

- solubility decreases as temperature decreases
- 1

Solution 3

(h)(iii)

Mark scheme

- none
- 1
- 0620/41
- October/November 2025

Question 3

0620/42 N25 ▪ Q3 ▪ 13 marks

3 A student prepares a sample of the insoluble salt barium sulfate, $BaSO_4$.
The student adds aqueous sodium sulfate, $Na_2SO_4(aq)$, to aqueous barium chloride, $BaCl_2(aq)$.

The student carries out the following steps.

step 1 Dissolve 0.100 moles of solid $BaCl_2$ in $100\,cm^3$ of distilled water in a beaker to form $BaCl_2(aq)$.

step 2 Add an aqueous solution which contains 0.100 moles of $Na_2SO_4(aq)$ to the beaker containing the $BaCl_2(aq)$ from **step 1**.

step 3 Stir the mixture and then filter it.

step 4 Dry the solid left in the filter paper.

(a) Complete the symbol equation for the reaction. Include state symbols.

Question 3

[2]

(b) Calculate the mass of solid $BaCl_2$ dissolved in **step 1**.

Question 3

(c) The concentration of $Na_2SO_4(aq)$ in **step 2** is $1.25\,mol/dm^3$.

Calculate the volume, in cm^3, of $1.25\,mol/dm^3$ $Na_2SO_4(aq)$ added in **step 2** which contains 0.100 moles of Na_2SO_4.

Question 3

(d) State the colour of the solid formed in **step 2**.

Question 3

(e) The mixture is filtered in **step 3**.

State the general term given to a solid left in the filter paper after filtration.

Question 3

(f) The actual mass of dry $BaSO_4$ collected in **step 4** is greater than the expected mass. This is because the student should do an additional step between **step 3** and **step 4**.

Suggest what the student should do in this additional step, and explain why the actual mass collected is greater than the expected mass.

Question 3

(g) State the name of this method of salt preparation.

Question 3

(h) State the name of a different:

Question 3

[3]

[Total: 13]

Solution 3

(a)

Mark scheme

- $\rightarrow$ BaSO4(s) + 2NaCl(aq) M1
- 2NaCl (only) M2
- (s) and (aq)
- 2

Solution 3

(b)

Mark scheme

- M1 Mr $BaCl_2 = 208$ M2
- $208 \times 0.1 = 20.8$
- 2

Solution 3

(c)

Mark scheme

- $0.100 \div 1.25\ (\times\ 1000) = 80\,(\text{cm3})$
- 1

Solution 3

(d)

Mark scheme

- white
- 1

Solution 3

(e)

Mark scheme

- residue
- 1

Solution 3

(f)

Mark scheme

- M1 rinsing the residue (with water) M2
- (mass was greater) because (dry) residue contains solid sodium chloride / NaCl adds to the mass (of residue)
- 2

Solution 3

(g)

Mark scheme

- precipitation
- 1

Solution 3

(h)

Mark scheme

- M1 named soluble barium salt other than barium chloride e.g. (barium) nitrate M2
- named soluble sulfate salt other than sodium sulphate e.g. potassium (sulfate) / ammonium (sulfate) M3
- named insoluble barium salt other than barium sulfate e.g. (barium) carbonate
- 3

Question 9

0620/21 J25 ▪ Q9 ▪ 1 mark

9 Calcium carbonate reacts with dilute hydrochloric acid.

The equation for the reaction is shown.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

1.00 g of calcium carbonate is added to 50.0 cm^3 of 0.0500 mol / dm^3 hydrochloric acid.

Which volume of carbon dioxide is made in this reaction?

A 30 cm^3 **B** 60 cm^3 **C** 120 cm^3 **D** 240 cm^3

Solution 9

Answer: **A**

Why

- Moles: $\mathrm{CaCO_3} = 1.00/100 = 0.0100$; $\mathrm{HCl} = 0.0500 \times 0.0500 = 0.00250$.
- The equation needs 2 mol of HCl per mol of $\mathrm{CaCO_3}$, so 0.0100 mol would need 0.0200 mol of acid.
- Only 0.00250 mol is present, so the acid is limiting and the carbonate is in large excess.

Question 20

0620/21 J25 ▪ Q20 ▪ 1 mark

20 The formulae of two hydrated salts are shown.

- $CuSO_4 \cdot xH_2O$
- $CoCl_2 \cdot yH_2O$

What are the values of *x* and *y*?

Question 20

	x	y
A	5	5
B	5	6
C	6	5
D	6	6

Solution 20

Answer: **B**

Why

- Hydrated copper(II) sulfate is the familiar blue $CuSO_4 \cdot 5H_2O$.
- Hydrated cobalt(II) chloride is $CoCl_2 \cdot 6H_2O$.
- So $x = 5$ and $y = 6$.

Question 9

0620/22 J25 ▪ Q9 ▪ 1 mark

9 The concentration of a solution of aqueous sodium hydroxide is $0.50\,\text{mol}/\text{dm}^3$.

Which mass of sodium hydroxide is used to make $500\,\text{cm}^3$ of this solution?

A 10 g **B** 20 g **C** 40 g **D** 160 g

Solution 9

Answer: **A**

Why

- Moles = concentration $\times$ volume in $\text{dm}^3 = 0.50 \times 0.500 = 0.25$ mol.
- M_r of NaOH $= 23 + 16 + 1 = 40$.
- Mass $= 0.25 \times 40 = 10$ g.

Question 12

0620/22 M25 ▪ Q12 ▪ 1 mark

12 The value of the Avogadro constant is 6.02×10^{23}.

What is the total number of atoms in 2.00 mol of ammonia gas?

A 1.20×10^{24} **B** 2.41×10^{24} **C** 4.82×10^{24} **D** 2.89×10^{25}

Solution 12

Answer: **C**

Why

- One NH_3 molecule contains four atoms: one N and three H.
- So 2.00 mol of ammonia holds 8.00 mol of atoms.
- $8.00 \times 6.02 \times 10^{23} = 4.82 \times 10^{24}$.