

M1. (a) (i) $pV = nRT$ (1)

(ii) Moles ethanol = $n = 1.36/46 (=0.0296 \text{ mol})$ (1)

$$V = nRT/p = \frac{0.0296 \times 8.31 \times 366}{100000} \quad (1)$$

if $V = p/nRT$ lose M3 and M4

$$= 8.996 \times 10^{-4} (\text{m}^3) \quad (1)$$

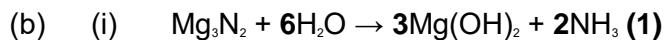
$$= 899 (900) \text{ cm}^3 \quad (1) \quad \text{range} = 895 - 905$$

If final answer = 0.899 award (2 + M1); if = 0.899 dm³ or if = 912 award (3 + M1)

Note: If 1.36 or 46 or 46/1.36 used as number of moles (n) then M2 and M4 not available

Note: If pressure = 100 then, unless answer = 0.899 dm³, deduct M3 and mark consequentially

5



$$(ii) \text{ Moles NH}_3 = \frac{0.263}{17} (=0.0155 \text{ mol}) \quad (1)$$

$$\text{Number of molecules of NH}_3 = 0.0155 \times 6.02 \times 10^{23} \quad (1)$$

$$[\text{mark conseq}] = 9.31 \times 10^{21} \quad (1)$$

$$[\text{range } 9.2 \times 10^{21} \text{ to } 9.4 \times 10^{21}]$$

Conseq (min 2 sig fig)

4

(c) Moles NaCl = $800/58.5$ (= 13.68) (1)

$$\text{Moles of NaHCO}_3 = 13.68 \quad (1)$$

$$\text{Moles of Na}_2\text{CO}_3 = 13.68/2 = 6.84 \quad (1)$$

$$\text{Mass of Na}_2\text{CO}_3 = 6.84 \times 106 = 725 \text{ g} \quad (1) \quad [\text{range} = 724 - 727]$$

[1450 g (range 1448 – 1454) is worth 3 marks]

Accept valid calculation method, e.g. reacting masses or calculations via the mass of sodium present. Also, candidates may deduce a direct 2:1 ratio for NaCl:Na₂CO₃

4

[13]

M2.C

[1]

M3.A

[1]

M4.A

[1]

M5.C

[1]

M6.B

[1]

M7.D

[1]

M8. (a) $L = \frac{1.0078}{1.6734 \times 10^{-24}}$ (1) or $\frac{\text{mass of 1 mol}}{\text{mass of 1 atom}}$
must show working

$$= 6.0225 \times 10^{23} \text{ (1)}$$

Ignore wrong units

NB answer only scores 1

2

(b) equal (1)

Or same or 1:1

1

(c) $PV = nRT$ (or $n = \frac{PV}{RT}$) (1)

$$= \frac{98000 \times 0.0352}{8.31 \times 298} \quad (1)$$

$$= 1.39 \quad (1)$$

Allow 1.390 to 1.395

ignore units even if incorrect
answer = 1.4 loses last mark

3

(d) $0.732 \times \frac{1000}{250} = 2.93 \quad (1) \text{ mol.dm}^{-3} \quad (1)$

OR M, mol/dm³, mol.l⁻¹

allow 2.928 to 2.93

Note unit mark tied to current answer but allow unit
mark if answer = 2.9 or 3

2

(e) (i) moles H₂SO₄ = $\frac{25}{1000} \times 1.24 = 0.0310 \quad (1)$

If use $m_1v_1 = m_2v_2$ scores 3 if answer is correct otherwise zero

$$\text{moles NH}_3 \text{ in } 30.8 \text{ cm}^3 = 0.0310 \times 2 = 0.0620 \quad (1)$$

Mark is for ×2

CE if × 2 not used

$$\text{moles of NH}_3 \text{ in } 1 \text{ dm}^3 = 0.620 \times \frac{1000}{30.8} = 2.01 \quad (1) \text{ (mol dm}^{-3}\text{)}$$

Allow 2.010 to 2.015

No units OK, wrong units lose last mark

(ii) moles $(\text{NH}_4)_2\text{SO}_4$ = moles H_2SO_4 = 0.310 (1)

*Allow consequential wrong moles in part (i) if clear
 $\text{H}_2\text{SO}_4 = (\text{NH}_4)\text{SO}_4$*

Wrong formula for $(\text{NH}_4)_2\text{SO}_4$ CE=0

$M_r (\text{NH}_4)_2\text{SO}_4 = 132.1$ (1)

Allow (132)

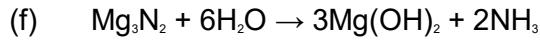
mass = moles $\times M_r = 0.0310 \times 132.1 = 4.10$ (1)

if moles of $(\text{NH}_4)_2\text{SO}_4$ not clear CE

(g) wrong unit loses mark

Allow 4.09 – 4.1 – 4.11

6



Formulae (1)

Balanced equation (1)

2

[16]

M9. (a) Ideal gas equation law (1)

1

(b) Moles of X: $n = \frac{PV}{RT}$ (1) = $\frac{110000 \times 2.34 \times 10^{-4}}{8.31 \times 473}$

= 6.55×10^{-3} (1)

6.5 to 6.6×10^{-3} , min 2 sig figs

$If write n = \frac{RT}{PV}$ zero here, but can score M_r

Relative molecular mass of X: $M_r = \frac{m}{n}$ (1)

= 62 (1)

61.5 to 62.5

4

(c) % oxygen = 51.6 (2)

$$\begin{array}{lll} C = 38.7 / 12 & H = 9.68 / 1 & O = 57.6(2) / 16 \\ & & \end{array} \quad \begin{array}{l} (1) \\ \\ \end{array}$$
$$\begin{array}{lll} = 3.23 & = 9.68 & = 3.23 \end{array}$$



If no % O or if wrong A_r used then max 1
Correct empirical formula earns all three marks

3

$$(d) \left(\frac{62}{31} \times \text{CH}_3\text{O} \right) = \text{C}_2\text{H}_6\text{O}_2 (1)$$

1

[9]

M10.D

[1]

M11. (a) (i) Number of moles of O₂ at equilibrium: $\frac{7.04}{32} = 0.22$ (1)

Number of moles of NO at equilibrium: 0.44 (1)
OR 2 × mol of oxygen

3

(ii) Original number of moles of NO₂: $\frac{21.3}{46} = 0.46(3)$ (1)

Number of moles of NO₂ at equilibrium:
0.46(3) – 0.44 = 0.02(3) (1)

OR consequent mol NO above

1

$$(b) \text{ Expression for } K_c: K_c = \frac{[\text{NO}]^2 [\text{O}_2]}{[\text{NO}_2]} \quad (1)$$

$$\text{Calculation: } K_c = \frac{\left(\frac{0.44}{11.5}\right)^2 \times \left(\frac{0.22}{11.5}\right)}{\left(\frac{0.023}{11.5}\right)^2} = 7.0(0) \text{ mol dm}^{-3}$$

(1) (1) (1)

If mol NO₂ = 0.02; K_c = 9.26 (9.3)

or consequent values from (a)

If vol missed, score only K_c and units

If K_c wrong: max 2 for correct use of vol and consequent units

If K_c wrong and no vol: max 1 for consequent units

3

$$(c) \text{ pV} = nRT \quad (1)$$

$$T = \frac{pV}{nR} = \frac{(3.30 \times 10^5) \times (11.5 \times 10^{-3})}{0.683 \times 8.31} =$$

(1) for using 11.5 × 10⁻³ as V

$$T = 669 \text{ K} \quad (1)$$

4

(d) Yield of oxygen: increased (1)

Value of K_c: no effect (1)

2

[13]