Q 1. diameter = 21 cm $\therefore r = \dfrac{21\text{ cm}}{2} = \underbrace{10.5\text{ cm} = 1.05\text{ dm}}_{\text{UNIT CONVERSION } 0.5}$

$$d = \underset{0.5}{\frac{m}{V}} = 1.18\ g/L = \frac{nM}{V} \quad 0.5$$

$$V_{SPHERE} = \frac{4}{3}\pi r^3 \quad 0.5$$

$$N_{He} = \underset{0.5}{n_{He}} N_A = \frac{dV}{M} N_A \quad 0.5$$

CORRECT SUBSTITUTIONS 1

$$= \frac{(1.18\,g/L)\,\frac{4}{3}\pi\,(1.05\text{ dm})^3\,6.022\times10^{23}\text{ ATOMS/mol}}{4.003\ g/mol}$$

$$= 8.6 \times 10^{23} \text{ ATOMS}$$

Q 2. $V_{FeCl_3} = 500.0\text{ mL}$ $\quad c_{FeCl_3} = 0.250\text{ M}$

$V_{BaCl_2} = 425.0\text{ mL}$ $\quad C_{BaCl_2} = 0.350\text{M}$

CORRECT MOLECULAR FORMULA 0.5

0.5

0.5

ADDING 2 TERMS 0.5

$$C_{Cl^-} = \underset{0.5}{\frac{n_{Cl^-}}{V_T}} = \frac{\underset{0.5}{C_{FeCl_3} V_{FeCl_3}} \times \overset{0.5}{\frac{3\text{ mol Cl}}{1\text{ mol FeCl}_3}} + C_{BaCl_2} V_{BaCl_2} \frac{2\text{mol Cl}}{1\text{mol FeCl}_2}}{\underbrace{500.0\text{ mL} + 425.0\text{ mL}}_{0.5}}$$

$$= \frac{(0.250\text{ M})(500.0\,\cancel{mL})(3) + (0.350\text{ M})(425\,\cancel{mL})(2)}{925\,\cancel{mL}}$$

0.5 CORRECT SUBSTITUTIONS

$$= 0.727\text{ M}$$

Q 3. $Ca_3(PO_4)_{2(s)} + 3H_2SO_{4(aq)} \longrightarrow 2H_3PO_{4(aq)} + 3CaSO_{4(aq)}$ BALANCE EQ'N 0.5

$m_{Ca_3(PO_4)_2} = 19.9\,g$ $\quad m_{H_2SO_4} = 54.3\,g$ $\quad m_{H_3PO_4,\,ACTUAL} = 10.9\,g$

LIMITING ?

1

$$n_{H_3PO_4} \text{ FROM } Ca_3(PO_4)_2 = \frac{m_{Ca_3(PO_4)_2}}{M_{Ca_3(PO_4)_2}} \times \frac{2\text{ mol } H_3PO_4}{1\text{ mol } Ca_3(PO_4)_2} = \frac{19.9\,g \times 2}{310.2\ g/mol} = 0.128\bar{3}\text{ mol}$$

1

$$n_{H_3PO_4} \text{ FROM } H_2SO_4 = \frac{m_{H_2SO_4}}{M_{H_2SO_4}} \times \frac{2\text{ mol } H_3PO_4}{3\text{ mol } H_2SO_4} = \frac{54.3\,g}{98.079\ \frac{g}{mol}} \times \frac{2}{3} = 0.369\bar{1}\text{ mol}$$

$\because n_{H_3PO_4}$ FROM $Ca_3(PO_4)_2$ IS SMALLER, $Ca_3(PO_4)_2$ IS LIMITING 0.5

$m_{H_3PO_4, THEORETICAL} = n_{H_3PO_4} M_{H_3PO_4}$ 1 $= (0.128\bar{3}\ mol)(97.994\ g/mol)$
$= 12.5\bar{7}\ g$

$\%\ YIELD = \frac{m_{ACTUAL}}{m_{THEORETICAL}} \times 100\%$ 1

$= \frac{10.9\ g}{12.5\bar{7}\ g} \times 100\% = 86.7\%$

Q4. $m_T = 100.00g$ $\quad m_T = m_{MgSO_4 \cdot 7H_2O} + m_{NaCl}$

$= m_{MgSO_4} + m_{H_2O} + m_{NaCl}$

$m_{MgSO_4} + m_{NaCl} = 65.75$ $\quad m_{H_2O} = 100.00g - 65.75g$
$= 34.25g$ 1

m_{MIX} NEEDED FOR $V = 1.000L$, $C_{Mg^{2+}} = 0.100\ M$?

$n_{Mg^{2+}} = C_{Mg^{2+}} V = 0.100\ mol$ 1

$m = n_{Mg} M = (0.100 mol)(24.305\ g/mol)$
$= 2.430\bar{5}\ g$ 1

IN 100 g SAMPLE

$n_{Mg} = n_{H_2O} \times \frac{1\ mol\ Mg}{7\ mol\ H_2O} = \frac{34.25g}{18.016\ g/mol} \times \frac{1}{7} = 0.27158\ mol$ 1

$\therefore m_{Mg} = n_{Mg} M_{Mg} = (0.271\bar{5}8\ mol)(24.305\ \frac{g}{mol})$

$= 6.601\bar{0}\ g$ 1

MASS % $MgSO_4$ $= \frac{m_{MgSO_4}}{m_T} \times 100\% = \frac{6.601\bar{0}\ g}{100.00} \times 100\% = 6.601\bar{0}\ \%$ 1

$\frac{m_{Mg, NEEDED}}{m_{MIXTURE}} = \frac{\%\ MASS}{100\%}$

$m_{MIXTURE} = \frac{m_{Mg, NEEDED}}{\%\ MASS} = \frac{2.430\bar{5}\ g}{0.06601\bar{0}}$ 1

$= 36.83g$

Q5: $n_{SO_2,\text{INITIAL}} = n_{O_2,\text{INITIAL}}$ 0.5

6 MARKS

$SO_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow SO_{3(g)}$ 0.5 $P_f = 2.55$ atm

	SO_2	O_2	SO_3
INITIAL	n	n	$\emptyset$
CHANGE	$-n$	$-\frac{1}{2}n$	n
FINAL	$\emptyset$	$\frac{1}{2}n$	n

1

$n_T = \frac{3}{2}n$ 0.5

χ: $\frac{\frac{1}{2}n}{\frac{3}{2}n} = \frac{1}{3}$ $\quad \frac{n}{\frac{3}{2}n} = \frac{2}{3}$ 0.5

$d_f? = \frac{m_f}{V}$ 0.5 $= \frac{n_T M_T}{V}$ 0.5

$M_T = \chi_{O_2} M_{O_2} + \chi_{SO_3} M_{SO_3}$ 0.5

$= \frac{1}{3} 32.00 \frac{g}{mol} + \frac{2}{3} 80.06 \frac{g}{mol}$

$= 64.04$ g/mol 0.5

$\frac{n}{V} = \frac{P}{RT}$ 0.5

$= \frac{P M_T}{RT}$ 0.5

$= \frac{(2.55\text{ atm})(64.04\text{ g/mol})}{(0.08206\text{ L·atm K}^{-1}\text{mol}^{-1})(298\text{K})}$ ← OTHER SUBS CORRECT 0.5

CORRECT R = 0.5

$= 6.68$ g/L

6. $C_{PE} = 0.1256 \frac{J}{°C\ g}$ $\quad T_{PE,\text{INITIAL}} = 200°C$

$V_{D_2O} = 1.00$ L $\quad C_{D_2O} = 4.211 \frac{J}{°C\cdot g}$ $\quad T_{D_2O,\text{INITIAL}} = 25.5°C$

$T_f = 31.3°C$

$d_{PE} = 21.45$ g/cm^3 $= \frac{m_{PE}}{V} = \frac{m_{PE}}{l^3}$

$d_{D_2O} = 1.11$ g/mL $\quad l = ?$

$$d_{PE}\,l^3 = m_{PE}$$

$$-q_{PE} = q_{D_2O} \quad 0.5$$

$$-\underline{m_{PE}\,C_{PE}}_{\,0.5}\,\Delta T_{PE} = \underline{m_{D_2O}\,C_{D_2O}}_{\,0.5}\,\Delta T_{D_2O}$$

$$-\underline{l^3}_{\,0.5}\,d_{PE}\,C_{PE}\,\Delta T_{PE} = \underline{d_{D_2O}\,V_{D_2O}}_{\,0.5}\,C_{D_2O}\,\Delta T_{D_2O}$$

REARRANGE 0.5

$$l^3 = \frac{-d_{D_2O}\,V_{D_2O}\,C_{D_2O}\,\Delta T_{D_2O}}{d_{PE}\,C_{PE}\,\Delta T_{PE}}$$

$$= \frac{-(1.11\ \tfrac{g}{\cancel{mL}})(1.00\,L)(4.211\ \tfrac{J}{\cancel{°C}\,g})\overbrace{(31.3\,\cancel{°C} - 25.5\,\cancel{°C})}^{0.5}}{(21.45\ \tfrac{g}{\cancel{mL}})(0.1256\ \tfrac{J}{\cancel{°C}\,g})\underbrace{(31.3\,\cancel{°C} - 200\,\cancel{°C})}_{0.5}}$$

$$l^3 = 0.05965\ dm^3$$

$$l = 0.391\ dm \times \frac{10\,cm}{1\,dm}$$

$$= 3.91\ cm$$