Chemistry 12
Resource Exam A
Scoring Guide

1. **(4 marks)**

In a fume hood, a student reacted copper and nitric acid in a flask according to the following equation:

$$Cu(s) + 4HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2H_2O(\ell) + 2NO_2(g)$$

The following data was collected:

Time (min)	Mass of flask and contents (g)
0.0	250.50
2.5	249.25
5.0	248.24
7.5	247.44

Calculate the overall rate of reaction in grams NO_2 per minute. **(1 mark)**

How much time will it take to react 0.50 g of Cu at this rate? **(3 marks)**

Solution:

For Example:

Calculate the overall rate of reaction in grams NO_2 per minute.

$$\text{rate} = \frac{(250.50\text{ g} - 247.44\text{ g})}{7.5\text{ min}} = 0.41\text{ g/min}$$ ← **1 mark**

How much time will it take to react 0.50 g of Cu at this rate?

$$\text{time(min)} = 0.50\text{ g Cu} \times \frac{1\text{ mol Cu}}{63.5\text{ g Cu}} \times \frac{2\text{ mol NO}_2}{1\text{ mol Cu}} \times \frac{46.0\text{ g NO}_2}{1\text{ mol NO}_2} \times \frac{1\text{ min}}{0.41\text{ g NO}_2}$$

$$= 1.8\text{ min}$$ ← **3 marks**

2. **(4 marks)**

Consider the following equilibrium:

$$CH_4(g) + 2H_2S(g) \leftrightarrows CS_2(g) + 4H_2(g)$$

Initially, 0.120 mol CH_4 and 0.280 mol H_2S were placed in a 2.00 L flask. At equilibrium, $[CS_2] = 0.030 \frac{\text{mol}}{\text{L}}$. Calculate K_{eq}.

Solution:

For Example:

	$CH_4(g)$ +	$2H_2S(g)$ ⇄	$CS_2(g)$ +	$4H_2(g)$	
I	0.0600	0.140	0	0	
C	–0.030	–0.060	+0.030	+0.120	
E	0.030	0.080	0.030	0.120	← **1 mark**

$$K_{eq} = \frac{[CS_2][H_2]^4}{[CH_4][H_2S]^2}$$

$$= \frac{(0.030)(0.120)^4}{(0.030)(0.080)^2}$$ } ← **1 mark**

$$= 0.032$$ ← **1 mark**

3. **(4 marks)**

Write the net ionic equation for the reaction that occurs when 40.0 mL of 1.50 M $AgNO_3$ is mixed with excess Na_2SO_4 solution, and calculate the mass of the precipitate that forms.

Solution:

For Example:

$$2Ag^+(aq) + SO_4{}^{2-}(aq) \rightarrow Ag_2SO_4(s) \qquad \leftarrow \textbf{1 mark}$$

$$\text{moles of } Ag^+ : 1.50\frac{\text{mol}}{\text{L}} \times 0.0400\ \text{L} \times \frac{1\ \text{mol } Ag^+}{1\ \text{mol } AgNO_3} = 0.0600\ \text{mol} \qquad \leftarrow \textbf{1 mark}$$

$$\text{Moles of } Ag_2SO_4 : 0.0600\ \text{mol} \times \frac{1\ \text{mol } Ag_2SO_4}{2\ \text{mol } Ag^+} = 0.0300\ \text{mol } Ag_2SO_4 \qquad \leftarrow \textbf{1 mark}$$

$$\text{Mass of } Ag_2SO_4 : 0.0300\ \text{mol} \times 311.9\frac{\text{g}}{\text{mol}} = 9.36\ \text{g} \qquad \leftarrow \textbf{1 mark}$$

4. **(3 marks)**

   Identify an amphiprotic substance and write two balanced equations that demonstrate its amphiprotic nature.

Solution:

For Example:

Amphiprotic substance: H_2O ← **1 mark**

H_2O behaving like an acid: $H_2O + F^- \leftrightarrows OH^- + HF$ ← **1 mark**

H_2O behaving like a base: $H_2O + HF \leftrightarrows H_3O^+ + F^-$ ← **1 mark**

5. **(5 marks)**

A 2.00 M diprotic acid (H_2X) has a pH of 0.60. Calculate its K_a value. Start by writing a general equation for the predominant equilibrium.

Solution:

For Example:

	$H_2X + H_2O(\ell) \rightleftarrows H_3O^+ + HX^-$	
[I]	2.00 M; 0; 0	
[C]	−0.25; +0.25; +0.25	
[E]	1.75; 0.25; 0.25	← **1 mark**

$pH = 0.60; [H_3O^+] = 0.25\ M$ ← **1 mark**

$$K_a = \frac{[H_3O^+][HX^-]}{[H_2X]}$$

$$= \frac{(0.25)(0.25)}{1.75}$$ ← **1 mark**

$$= 0.036$$ ← **1 mark**

6. **(3 marks)**

A titration was performed by adding $0.125\ M\ NaOH$ to a 25.00 mL sample of H_2SO_4. Calculate the $[H_2SO_4]$ from the following data.

	Trial #1	**Trial #2**	**Trial #3**
Initial volume of NaOH (mL)	4.00	17.05	8.00
Final volume of NaOH (mL)	17.05	28.00	19.05

Solution:

For Example:

	Trial #1	**Trial #2**	**Trial #3**
NaOH added (mL)	13.05	10.95	11.05

↑ **discard**

average NaOH added = 11.00 mL = 0.01100 L

$(H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2HOH(\ell))$

$$[H_2SO_4] = \frac{0.125\ \text{mol NaOH}}{\text{L}} \times 0.01100\text{L} \times \frac{1\ \text{mol } H_2SO_4}{2\ \text{mol NaOH}} \times \frac{1}{0.02500\ \text{L}}$$

$= 0.0275\ M$ ↑ **1 mark** ↑ **1 mark** ↑ **1 mark**

7. **(4 marks)**

Balance the following in acidic solution.

$$BiO_3^- + I_3^- \rightarrow Bi^{3+} + IO_3^- \qquad \text{(acidic)}$$

Solution:

For Example:

$$8\left(BiO_3^- + 6H^+ + 2e^- \rightarrow Bi^{3+} + 3H_2O\right) \qquad \leftarrow \textbf{1 mark}$$

$$1\left(I_3^- + 9H_2O \rightarrow 3IO_3^- + 18H^+ + 16e^-\right) \qquad \leftarrow \textbf{1 mark}$$

$$8BiO_3^- + 48H^+ + I_3^- + 9H_2O \rightarrow 8Bi^{3+} + 24H_2O + 3IO_3^- + 18H^+ \qquad \leftarrow \textbf{1 mark for balancing}$$

$$8BiO_3^- + 30H^+ + I_3^- \rightarrow 8Bi^{3+} + 15H_2O + 3IO_3^- \qquad \leftarrow \textbf{1 mark}$$

8. **(3 marks)**

Draw an operating electrolytic cell used in the electrolysis of molten sodium chloride, NaCl. Label the anode and cathode.

Solution:

For Example: