INSERT STUDENT I.D. NUMBER (PEN)

STICKER IN THIS SPACE

AUGUST 1997

PROVINCIAL EXAMINATION

MINISTRY OF EDUCATION, SKILLS AND TRAINING

CHEMISTRY 12

GENERAL INSTRUCTIONS

1. Insert the stickers with your Student I.D. Number (PEN) in the allotted spaces above. **Under no circumstance is your name or identification, other than your Student I.D. Number, to appear on this paper.**

2. Take the separate Answer Sheet and follow the directions on its front page.

3. Be sure you have an **HB pencil** and an eraser for completing your Answer Sheet. Follow the directions on the Answer Sheet when answering multiple-choice questions.

4. For each of the written-response questions, write your answer in the space provided.

5. When instructed to open this booklet, **check the numbering of the pages** to ensure that they are numbered in sequence from page one to the last page, which is identified by

   END OF EXAMINATION.

6. At the end of the examination, place your Answer Sheet inside the front cover of this booklet and return the booklet and your Answer Sheet to the supervisor.

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INSERT STUDENT I.D. NUMBER (PEN)

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CHEMISTRY 12 AUGUST 1997 PROVINCIAL

Course Code = CH Examination Type = P

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10. _____ (3)

11. _____ (4)

12. _____ (4)

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CHEMISTRY 12 PROVINCIAL EXAMINATION

		Value	Suggested Time
1.	This examination consists of **two** parts:		
	PART A: 48 multiple-choice questions	48	70
	PART B: 12 written-response questions	32	50
	Total:	**80 marks**	**120 minutes**

2. The following tables can be found in the separate **Data Booklet:**
   - Periodic Table of the Elements
   - Atomic Masses of the Elements
   - Names, Formulae, and Charges of Some Common Ions
   - Solubility of Common Compounds in Water
   - Solubility Product Constants at 25° C
   - Relative Strengths of Brönsted-Lowry Acids and Bases
   - Acid-Base Indicators
   - Standard Reduction Potentials of Half-cells

   No other reference materials or tables are allowed.

3. An approved scientific calculator is essential for the examination. The calculator must be a hand-held device designed **only** for mathematical computations such as logarithmic and trigonometric functions. It **can be** programmable, but **must not** contain any graphing capabilities. You **must not** bring into the examination room any devices to support calculators such as manuals, printed or electronic cards, printers, memory expansion chips or cards, or keyboards.

4. You have **two hours** to complete this examination.

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PART A: MULTIPLE CHOICE

Value: 48 marks **Suggested Time: 70 minutes**

INSTRUCTIONS: For each question, select the **best** answer and record your choice on the Answer Sheet provided. Using an HB pencil, completely fill in the circle that has the letter corresponding to your answer.

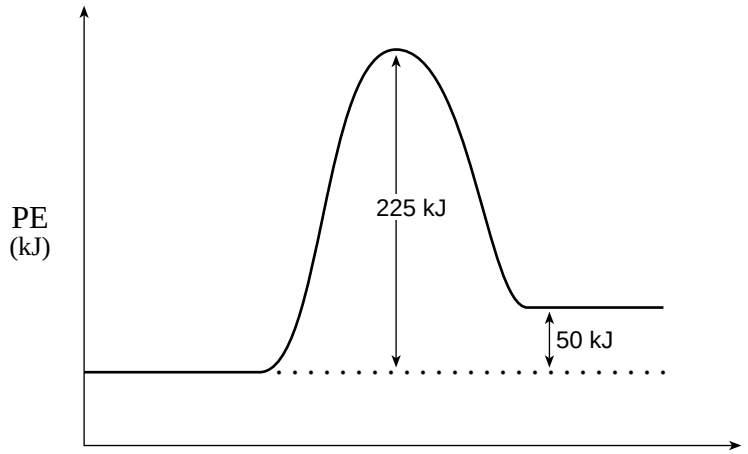
1. Magnesium metal reacts rapidly with hydrochloric acid in an open beaker to produce aqueous magnesium chloride and hydrogen gas. Which of the following could be used to measure the rate of this reaction?

   A. the volume of the solution
   B. the colour of gas produced
   C. the concentration of the chloride ion
   D. the mass of the beaker and its contents

2. To increase the rate of a reaction, there must be

   A. a decrease in the frequency of collisions.
   B. an increase in the frequency of collisions.
   C. a decrease in the frequency of successful collisions.
   D. an increase in the frequency of successful collisions.

3. Consider the following potential energy diagram:



   The forward reaction is

   A. exothermic and the $\Delta H = -50$ kJ
   B. endothermic and the $\Delta H = +50$ kJ
   C. exothermic and the $\Delta H = -225$ kJ
   D. endothermic and the $\Delta H = +225$ kJ

OVER

4. A catalyst increases the rate of a reaction by providing an alternate reaction mechanism that has a

   A. lower ΔH.
   B. higher ΔH.
   C. lower activation energy.
   D. higher activation energy.

5. Consider the following reaction mechanism:

$$O_{3(g)} + NO_{(g)} \rightarrow NO_{2(g)} + O_{2(g)}$$
$$NO_{2(g)} + O_{(g)} \rightarrow NO_{(g)} + O_{2(g)}$$

   The product in the overall reaction is

   A. O_2
   B. O_3
   C. NO
   D. NO_2

6. Consider the following equilibrium:

$$H_2O_{(g)} + CO_{(g)} \rightleftarrows H_{2(g)} + CO_{2(g)}$$

   A closed container is initially filled with H_2O and CO. As the reaction proceeds towards equilibrium the

   A. $[CO]$ and $[CO_2]$ both increase.
   B. $[CO]$ and $[CO_2]$ both decrease.
   C. $[CO]$ increases and $[CO_2]$ decreases.
   D. $[CO]$ decreases and $[CO_2]$ increases.

7. Equilibrium is a dynamic process because the

   A. macroscopic properties are not changing.
   B. mass of reactants equals the mass of products.
   C. forward and reverse reactions continue to occur.
   D. concentrations of the reactants and products are constant.

8. Consider the following equilibrium:

$$SO_{2(g)} + NO_{2(g)} \rightleftarrows SO_{3(g)} + NO_{(g)} + \text{energy}$$

The equilibrium does **not** shift with a change in the

A. volume.
B. temperature.
C. concentration of products.
D. concentration of reactants.

9. Consider the following equilibrium:

$$SO_2Cl_{2(g)} + \text{energy} \rightleftarrows SO_{2(g)} + Cl_{2(g)}$$

When the temperature is decreased, the equilibrium shifts

A. left and $[SO_2Cl_2]$ increases.
B. left and $[SO_2Cl_2]$ decreases.
C. right and $[SO_2Cl_2]$ increases.
D. right and $[SO_2Cl_2]$ decreases.

10. Consider the following equilibrium:

$$2N_2O_{(g)} + 3O_{2(g)} \rightleftarrows 4NO_{2(g)}$$

The equilibrium constant expression is

A. $K_{eq} = \dfrac{[2N_2O][3O_2]}{[4NO_2]}$

B. $K_{eq} = \dfrac{[N_2O]^2[O_2]^3}{[NO_2]^4}$

C. $K_{eq} = \dfrac{[4NO_2]}{[2N_2O][3O_2]}$

D. $K_{eq} = \dfrac{[NO_2]^4}{[N_2O]^2[O_2]^3}$

OVER

11. Consider the following equilibrium:

$$2NO_{(g)} \rightleftarrows N_{2(g)} + O_{2(g)} \qquad K_{eq} = 2.1 \times 10^{30}$$

The value of the equilibrium constant indicates that the

A. $[NO]^2 < [N_2][O_2]$
B. $[NO]^2 > [N_2][O_2]$
C. $[NO] = [N_2][O_2]$
D. $[NO] > [N_2][O_2]$

12. Consider the following equilibrium:

$$H_{2(g)} + I_{2(g)} \rightleftarrows 2HI_{(g)}$$

At equilibrium the $[H_2] = 0.020$ mol/L, $[I_2] = 0.020$ mol/L and $[HI] = 0.160$ mol/L. The value of the equilibrium constant is

A. 2.5×10^{-3}
B. 1.6×10^{-2}
C. 6.4×10^{1}
D. 4.0×10^{2}

13. Consider the following equilibrium:

$$H_2O_{(g)} + Cl_2O_{(g)} \rightleftarrows 2HOCl_{(g)} \qquad K_{eq} = 9.0 \times 10^{-2}$$

A 1.0 L flask contains a mixture of 1.8×10^{-1} mol H_2O, 4.0×10^{-4} mol Cl_2O, and 8.0×10^{-2} mol $HOCl$. To establish equilibrium, the system will proceed to the

A. left because Trial $K_{eq} > K_{eq}$
B. left because Trial $K_{eq} < K_{eq}$
C. right because Trial $K_{eq} > K_{eq}$
D. right because Trial $K_{eq} < K_{eq}$

14. The equation representing the equilibrium in a saturated solution of $CaSO_4$ is

A. $CaSO_{4(s)} \rightleftarrows Ca^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$

B. $CaSO_{4(s)} \rightleftarrows Ca^{2+}_{(aq)} + S^{2-}_{(aq)} + 4O^{2-}_{(aq)}$

C. $CaSO_{4(s)} + H_2O_{(\ell)} \rightleftarrows CaO_{(aq)} + H_2SO_{4(aq)}$

D. $CaSO_{4(s)} + 2H_2O_{(\ell)} \rightleftarrows Ca(OH)_{2(aq)} + H_2SO_{4(aq)}$

15. A solution contains a mixture of SO_4^{2-} and S^{2-}. Which of the following cations could be used to remove only the SO_4^{2-} from the solution by precipitation?

A. K^+

B. Sr^{2+}

C. Pb^{2+}

D. Cu^{2+}

16. The **least** soluble salt in water is

A. BaS

B. $AlCl_3$

C. $CaSO_3$

D. $ZnSO_4$

17. When 0.20 M $Al_2(SO_4)_3$ is added to an equal volume of 0.20 M $CaCl_2$,

A. $AlCl_3$ precipitates.

B. $CaSO_4$ precipitates.

C. $AlCl_3$ and $CaSO_4$ precipitate.

D. no precipitate forms.

18. The solubility of barium oxalate, BaC_2O_4, is 4.8×10^{-4} M. The value of K_{sp} is

A. 2.3×10^{-7}

B. 4.8×10^{-4}

C. 2.4×10^{-4}

D. 2.2×10^{-2}

OVER

19. The solubility of $AgBrO_3$ is

A. 2.8×10^{-9} M
B. 5.3×10^{-5} M
C. 1.1×10^{-4} M
D. 7.3×10^{-3} M

20. Consider the following equilibrium:

$$MgCO_{3(s)} \rightleftarrows Mg^{2+}_{(aq)} + {CO_3}^{2-}_{(aq)}$$

A saturated solution of $MgCO_3$ is in contact with undissolved solute. More $MgCO_{3(s)}$ can be dissolved by adding solid

A. oxalic acid.
B. sodium carbonate.
C. magnesium chloride.
D. magnesium carbonate.

21. Which of the following is a general property common to both acidic and basic solutions?

A. tastes sour
B. feels slippery
C. reacts with metals
D. conducts electricity

22. The equation for the predominant reaction between HSO_3^- and H_2O is

A. $HSO_3^- + H_2O \rightleftarrows H_2SO_4 + H^+$
B. $HSO_3^- + H_2O \rightleftarrows {SO_3}^{2-} + H_3O^+$
C. $HSO_3^- + H_2O \rightleftarrows H_2SO_3 + OH^-$
D. $HSO_3^- + H_2O \rightleftarrows H_2SO_4 + \frac{1}{2}H_2$

23. A base is converted to its conjugate acid by

A. adding a proton.
B. adding an electron.
C. removing a proton.
D. removing an electron.

24. Consider the following:

I	H_3PO_4
II	$H_2PO_4^-$
III	HPO_4^{2-}
IV	PO_4^{3-}

Which of the above are amphiprotic in an aqueous solution?

A. I and II only
B. II and III only
C. I, II and III only
D. II, III and IV only

25. Which of the following solutions will have the largest $\left[H_3O^+\right]$?

A. 1.0 M HNO_2
B. 1.0 M H_3BO_3
C. 1.0 M $H_2C_2O_4$
D. 1.0 M HCOOH

26. Consider the following:

$$2H_2O_{(\ell)} + 57\ \text{kJ} \rightleftarrows H_3O^+_{(aq)} + OH^-_{(aq)}$$

When the temperature of the above system is increased, the equilibrium shifts

A. left and K_w increases.
B. left and K_w decreases.
C. right and K_w increases.
D. right and K_w decreases.

OVER

27. The $\left[OH^-\right]$ in an aqueous solution always equals

A. $K_w \times \left[H_3O^+\right]$

B. $K_w - \left[H_3O^+\right]$

C. $\dfrac{K_w}{\left[H_3O^+\right]}$

D. $\dfrac{\left[H_3O^+\right]}{K_w}$

28. The $\left[H_3O^+\right]$ in a solution with pOH of 0.253 is

A. 5.58×10^{-15} M

B. 1.79×10^{-14} M

C. 5.58×10^{-1} M

D. 5.97×10^{-1} M

29. The equilibrium constant expression for the predominant hydrolysis reaction in 1.0 M K_2HPO_4 is

A. $K_{eq} = \dfrac{\left[H_2PO_4^-\right]\left[OH^-\right]}{\left[HPO_4^{2-}\right]}$

B. $K_{eq} = \dfrac{\left[H_3PO_4\right]\left[OH^-\right]}{\left[H_2PO_4^-\right]}$

C. $K_{eq} = \dfrac{\left[K^+\right]\left[KHPO_4^-\right]}{\left[K_2HPO_4\right]}$

D. $K_{eq} = \dfrac{\left[K^+\right]^2\left[HPO_4^{2-}\right]}{\left[K_2HPO_4\right]}$

30. The solution with the highest pH is

A. 1.0 M NaCl

B. 1.0 M NaCN

C. 1.0 M $NaIO_3$

D. 1.0 M Na_2SO_3

31. Consider the following:

I	$H_2CO_3 + F^- \rightleftarrows HCO_3^- + HF$
II	$HCO_3^- + HC_2O_4^- \rightleftarrows H_2CO_3 + C_2O_4^{2-}$
III	$HCO_3^- + H_2C_6H_5O_7^- \rightleftarrows H_2CO_3 + HC_6H_5O_7^{2-}$

The HCO_3^- is a base in

A. I only
B. I and II only
C. II and III only
D. I, II and III

32. Consider the following equilibrium for an indicator:

$$HInd + H_2O \rightleftarrows Ind^- + H_3O^+$$

When a few drops of the indicator methyl red are added to 1.0 M HCl, the colour of the resulting solution is

A. red and the products are favoured.
B. red and the reactants are favoured.
C. yellow and the products are favoured.
D. yellow and the reactants are favoured.

33. The pH at the equivalence point of a strong acid–strong base titration is

A. equal to 0.00
B. less than 7.00
C. equal to 7.00
D. greater than 7.00

34. The volume of 0.450 M HCl needed to neutralize 40.0 mL of 0.450 M $Sr(OH)_2$ is

A. 18.0 mL
B. 20.0 mL
C. 40.0 mL
D. 80.0 mL

OVER

35. Consider the following:

$$CH_3COOH + H_2O \rightleftarrows CH_3COO^- + H_3O^+$$

A buffer solution is prepared by adding $NaCH_3COO_{(s)}$ to $CH_3COOH_{(aq)}$. When a few drops of NaOH solution are added to the buffer, the equilibrium

A. shifts left and $\left[CH_3COO^-\right]$ increases.
B. shifts left and $\left[CH_3COO^-\right]$ decreases.
C. shifts right and $\left[CH_3COO^-\right]$ increases.
D. shifts right and $\left[CH_3COO^-\right]$ decreases.

36. A basic solution can be prepared from

A. NO
B. SrO
C. CO_2
D. SO_3

37. Consider the following redox reaction:

$$6H^+ + 6I^- + ClO_3^- \rightarrow 3I_2 + 3H_2O + Cl^-$$

The reducing agent is

A. I^-
B. I_2
C. H^+
D. ClO_3^-

38. A substance is oxidized when it

A. loses protons.
B. gains protons.
C. loses electrons.
D. gains electrons.

39. Which equation represents a redox reaction?

A. $Pb^{2+} + 2Cl^- \rightarrow PbCl_2$
B. $CaO + CO_2 \rightarrow CaCO_3$
C. $Mg + 2HCl \rightarrow MgCl_2 + H_2$
D. $HCl + NaOH \rightarrow NaCl + H_2O$

40. The two species which react spontaneously in acidic solutions are

A. IO_3^- and I_2
B. SO_4^{2-} and S
C. BrO_3^- and Br^-
D. $AuCl_4^-$ and Au

41. A strip of titanium, Ti, is placed in 1.0 M $Sn(NO_3)_2$. The shiny surface of the titanium darkens, indicating that a reaction has occurred. From this observation it may be concluded that

A. Ti^{2+} is a weaker reducing agent than Sn^{2+}
B. Ti^{2+} is a weaker oxidizing agent than Sn^{2+}
C. Ti^{2+} is a stronger reducing agent than Sn^{2+}
D. Ti^{2+} is a stronger oxidizing agent than Sn^{2+}

42. Nitrogen has an oxidation number of zero in

A. N_2
B. NO_2
C. NH_3
D. HNO_3

43. Consider the following redox reaction:

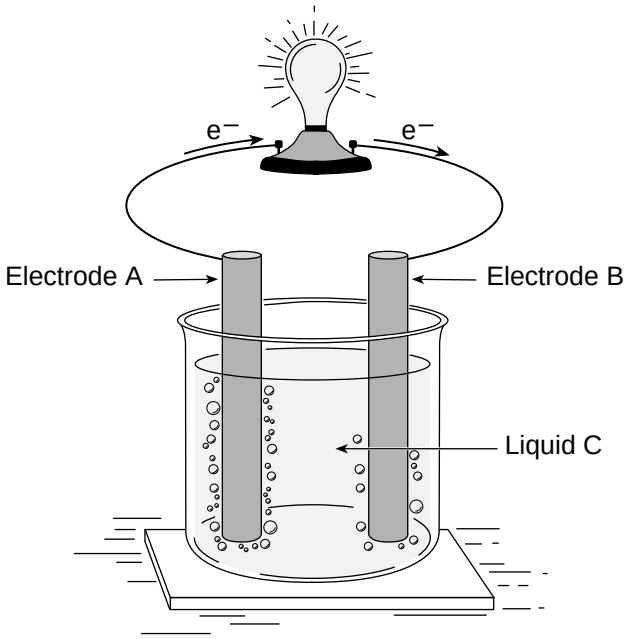
$$2HNO_3 + 3H_2S \rightarrow 2NO + 3S + 4H_2O$$

The nitrogen in HNO_3 undergoes

A. reduction.
B. oxidation.
C. electrolysis.
D. neutralization.

OVER

Use the following diagram to answer questions 44 and 45.



44. Under which conditions will a 2.0 V electric bulb be lit?

	ELECTRODE A	ELECTRODE B	LIQUID C
A.	Cu	Mg	H_2O
B.	Mg	Cu	H_2O
C.	Cu	Mg	1.0 M HCl
D.	Mg	Cu	1.0 M HCl

45. The gas formed at electrode **B** is

A. O_2
B. H_2
C. Cl_2
D. H_2O

46. Which method will cathodically protect a piece of iron?

A. Paint the iron.
B. Cover the iron with grease.
C. Attach a piece of lead to the iron.
D. Attach a piece of magnesium to the iron.

47. Which of the following aqueous solutions produces $H_{2(g)}$ and $O_{2(g)}$ during electrolysis?

A. 1.0 M KI
B. 1.0 M CuI_2
C. 1.0 M K_2SO_4
D. 1.0 M $CuSO_4$

48. An industrial process involving electrolysis is the reduction of

A. water forming oxygen gas.
B. water forming hydrogen gas.
C. sea water forming chlorine gas.
D. sea water forming bromine liquid.

This is the end of the multiple-choice section.
Answer the remaining questions directly in this examination booklet.

OVER

PART B: WRITTEN RESPONSE

Value: 32 marks **Suggested Time: 50 minutes**

INSTRUCTIONS:	You will be expected to communicate your knowledge and understanding of chemical principles in a clear and logical manner. Your steps and assumptions leading to a solution must be written in the spaces below the questions. Answers must include units where appropriate and be given to the correct number of significant figures. **For questions involving calculation, full marks will NOT be given for providing only an answer.**

1. Define the term *activation energy*. **(2 marks)**

_____

_____

_____

_____

Score for Question 1:

1. _____ (2)

2. Consider the overall reaction:

$$4HBr_{(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)} + 2Br_{2(g)}$$

A proposed three-step reaction mechanism is:

Step 1: $HBr + O_2 \rightarrow HOOBr$

Step 2: ?

Step 3: $HBr + HOBr \rightarrow H_2O + Br_2$

Write the equation for Step 2. **(2 marks)**

Score for Question 2:

2. _____ (2)

3. Consider the following equilibrium:

$$2NO_{(g)} + Cl_{2(g)} \rightleftarrows 2NOCl_{(g)} \qquad \Delta H = -77 \text{ kJ}$$

What happens to the amount of Cl_2 when the following changes are imposed? Explain, using Le Chatelier's principle.

a) Removing $NO_{(g)}$. **(1 mark)**

b) Decreasing the temperature. **(1 mark)**

Score for Question 3:

3. _____ (2)

4. Consider the following equilibrium:

$$H_{2(g)} + S_{(s)} \rightleftarrows H_2S_{(g)} \qquad K_{eq} = 6.8 \times 10^{-2}$$

A 1.0 L container is initially filled with 0.050 mol H_2 and 0.050 mol S. The container is heated to $90^\circ C$ and equilibrium is established. What is the equilibrium $[H_2S]$? **(3 marks)**

Score for Question 4:

4. _____ (3)

OVER

5. A container is filled with 10.0 L of 0.050 M NaI. Calculate the maximum mass of solid $Pb(NO_3)_2$ that can be dissolved without forming a precipitate. **(3 marks)**

Score for Question 5:
5. _____ (3)

6. Write net ionic equations for all precipitation reactions that occur when equal volumes of 0.20 M $Sr(OH)_2$ and 0.20 M $MgSO_4$ are mixed together. **(2 marks)**

Score for Question 6:
6. _____ (2)

7. State two tests that could be safely performed to determine whether an unknown solution is acidic. Predict the results if the solution is acidic. **(2 marks)**

Test 1: _____

Result: _____

Test 2: _____

Result: _____

Score for Question 7:

7. _____ (2)

8. An aqueous solution of Na_2CO_3 undergoes hydrolysis.

a) Write the equation for the hydrolysis. **(1 mark)**

b) Calculate K_b for the hydrolysis in a). **(1 mark)**

Score for Question 8:

8. _____ (2)

OVER

9. A solution of 0.0100 M lactic acid, $HC_3H_5O_3$, has a pH of 2.95.
Calculate the K_a value. **(3 marks)**

Score for Question 9:
9. _____ (3)

10. Calculate the pH of a solution prepared by adding 40.0 mL of 0.440 M NaOH to 60.0 mL of 0.320 M HCl. **(3 marks)**

Score for Question 10:
10. _____ (3)

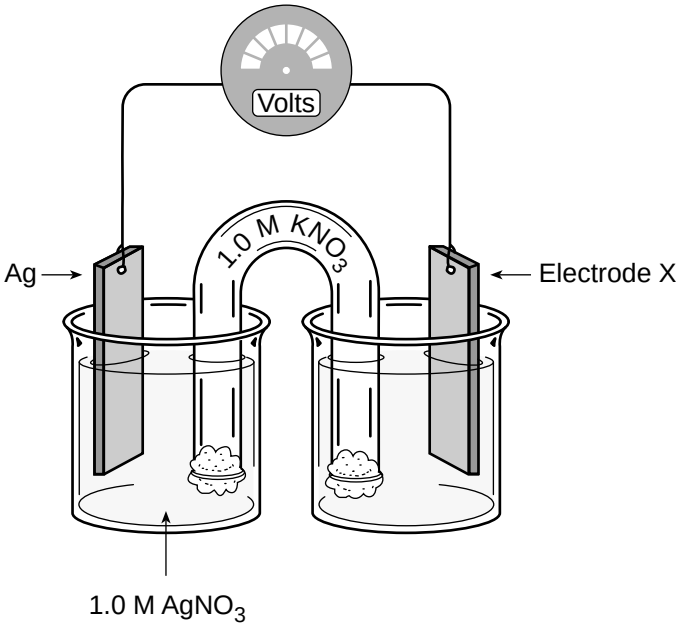
11. Balance the following redox reaction: **(4 marks)**

$$Mn^{2+} + BiO_3^- \rightarrow MnO_4^- + Bi^{3+} \quad \text{(acidic)}$$

Score for Question 11:
11. _____ (4)

OVER

12. Consider the following electrochemical cell:



a) The initial cell voltage in the diagram above is 1.25 V. Identify electrode **X**. **(1 mark)**

_____

b) Towards which electrode will the K^+ ions migrate? **(1 mark)**

_____

c) Write the equation for the reduction half-reaction that occurs. **(1 mark)**

d) On the diagram, indicate the direction of electron flow. **(1 mark)**

Score for Question 12:
12. _____ (4)

END OF EXAMINATION