INSERT STUDENT I.D. NUMBER (PEN)

STICKER IN THIS SPACE

JANUARY 1996

PROVINCIAL EXAMINATION

MINISTRY OF EDUCATION

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 JANUARY 1996 PROVINCIAL

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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: 11 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. Consider the following reaction:

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

Under certain conditions, the rate of decomposition of NO_2 is 3.2×10^{-3} mol/s. The rate of formation of O_2 is

A. 1.6×10^{-3} mol/s
B. 3.2×10^{-3} mol/s
C. 4.8×10^{-3} mol/s
D. 6.4×10^{-3} mol/s

2. Consider the following reactions:

I. $N_{2(g)} + O_{2(g)} \rightarrow 2NO_{(g)}$
II. $2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$
III. $CaCO_{3(s)} + 2H^{+}_{(aq)} \rightarrow Ca^{2+}_{(aq)} + H_2O_{(\ell)} + CO_{2(g)}$

Increasing the surface area will increase the reaction rate in

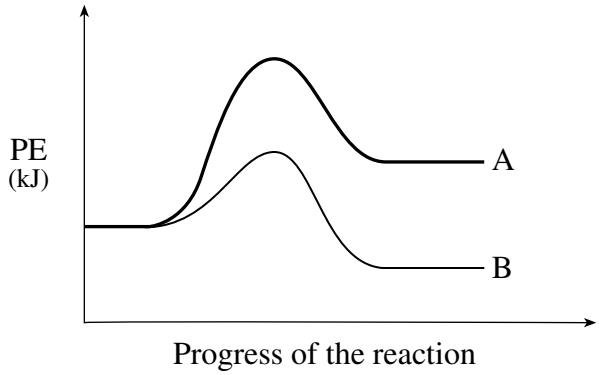
A. II only
B. I and III only
C. II and III only
D. I, II and III

3. A catalyst increases the rate of a reaction by

A. increasing the concentration of the reactant(s).
B. decreasing the concentration of the reactant(s).
C. increasing the activation energy of the overall reaction.
D. decreasing the activation energy of the overall reaction.

OVER

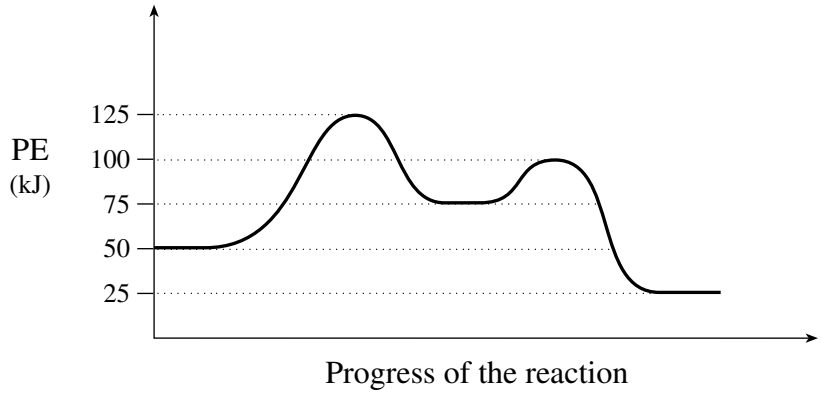
4. Consider the following potential energy diagram that represents two different reactions.



Which of the following statements is correct?

A. Reactions A and B are both exothermic.
B. Reactions A and B are both endothermic.
C. Reaction A is exothermic and reaction B is endothermic.
D. Reaction A is endothermic and reaction B is exothermic.

5. Consider the following potential energy diagram:



The activation energy for the **forward** reaction is

A. 25 kJ
B. 50 kJ
C. 75 kJ
D. 125 kJ

6. Consider the following reaction mechanism:

Step 1: $ICl + H_2 \rightarrow HI + HCl$ (slow)

Step 2: $ICl + HI \rightarrow HCl + I_2$ (fast)

The species HCl is a

A. product.
B. catalyst.
C. reactant.
D. reaction intermediate.

7. In which of the following does the entropy decrease?

A. $NaCl_{(s)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)}$
B. $4NO_{(g)} + 6H_2O_{(g)} \rightarrow 4NH_{3(g)} + 5O_{2(g)}$
C. $2NaHCO_{3(s)} \rightarrow Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(g)}$
D. $CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(\ell)}$

8. Consider the following equilibrium:

$$H_{2(g)} + CO_{2(g)} \rightleftarrows CO_{(g)} + H_2O_{(g)} \qquad \Delta H = +41 \text{ kJ}$$

The temperature of the above equilibrium system is increased while kept at a constant volume. A new state of equilibrium is established in which there is

A. an increase in $[CO]$ and a decrease in K_{eq}
B. an increase in $[CO]$ and an increase in K_{eq}
C. an increase in $[CO_2]$ and a decrease in K_{eq}
D. an increase in $[CO_2]$ and an increase in K_{eq}

OVER

9. Consider the following equilibrium:

$$2SO_{3(g)} \rightleftarrows 2SO_{2(g)} + O_{2(g)}$$

The volume of the system is decreased at a constant temperature. A new state of equilibrium is established by a shift of the original equilibrium to the

A. left and $[SO_3]$ increases.

B. right and $[SO_3]$ decreases.

C. left and $[SO_3]$ remains unchanged.

D. right and $[SO_3]$ remains unchanged.

10. Consider the following equilibrium:

$$2H_2S_{(g)} \rightleftarrows 2H_{2(g)} + S_{2(g)}$$

At equilibrium, $[H_2S] = 0.50$ mol/L, $[H_2] = 0.10$ mol/L and $[S_2] = 0.40$ mol/L.
The value of K_{eq} is calculated using the ratio

A. $\dfrac{(0.10)(0.40)}{(0.50)}$

B. $\dfrac{(0.10)^2(0.40)}{(0.50)^2}$

C. $\dfrac{(0.50)}{(0.10)(0.50)}$

D. $\dfrac{(0.50)^2}{(0.10)^2(0.40)}$

11. Consider the following equilibrium:

$$I_{2(s)} + H_2O_{(\ell)} \rightleftarrows H^+_{(aq)} + I^-_{(aq)} + HOI_{(aq)}$$

The equilibrium constant expression for the above system is

A. $K_{eq} = [H^+][I^-]$

B. $K_{eq} = [H^+][I^-][HOI]$

C. $K_{eq} = \dfrac{[H^+][I^-][HOI]}{[I_2][H_2O]}$

D. $K_{eq} = \dfrac{[H^+][I^-][HOI]}{[H_2O]}$

12. In an exothermic equilibrium reaction involving only gases, the value of K_{eq} can be **decreased** by

A. adding some reactant gas.
B. removing some reactant gas.
C. increasing the temperature.
D. decreasing the temperature.

13. Consider the following equilibrium:

$$2NO_{(g)} + Cl_{2(g)} \rightleftarrows 2NOCl_{(g)} \qquad K_{eq} = 12$$

At equilibrium, $[NOCl] = 1.60$ mol/L and $[NO] = 0.80$ mol/L. The $[Cl_2]$ is

A. 0.17 mol/L
B. 0.27 mol/L
C. 0.33 mol/L
D. 3.0 mol/L

OVER

14. The equation that represents the equilibrium in a saturated solution of $Fe_2(SO_4)_3$ is

A. $Fe_2(SO_4)_{3(s)} \rightleftarrows 3Fe^{2+}_{(aq)} + 2SO_4{}^{3-}_{(aq)}$

B. $Fe_2(SO_4)_{3(s)} \rightleftarrows 2Fe^{2+}_{(aq)} + 3SO_4{}^{3-}_{(aq)}$

C. $Fe_2(SO_4)_{3(s)} \rightleftarrows 3Fe^{3+}_{(aq)} + 2SO_4{}^{2-}_{(aq)}$

D. $Fe_2(SO_4)_{3(s)} \rightleftarrows 2Fe^{3+}_{(aq)} + 3SO_4{}^{2-}_{(aq)}$

15. A solution of $AgNO_3$ is slowly added to a mixture containing $0.10\ M$ I^-, Cl^-, Br^- and $IO_3{}^-$. The precipitate which forms first is

A. AgI

B. AgCl

C. AgBr

D. $AgIO_3$

16. Which of the following ions could be used to separate $Cl^-_{(aq)}$ from $SO_4{}^{2-}_{(aq)}$ by precipitation?

A. Ag^+

B. Ca^{2+}

C. $NH_4{}^+$

D. Pb^{2+}

17. Which of the following could be used to precipitate both Mg^{2+} and Ca^{2+} from hard water?

A. lithium sulphate
B. sodium phosphate
C. potassium sulphide
D. ammonium chloride

18. The solubility of manganese(II) sulphide is $1.7\times10^{-7}\,M$ at $25°C$. The solubility product constant is

A. 2.9×10^{-14}

B. 1.7×10^{-7}

C. 3.4×10^{-7}

D. 4.1×10^{-4}

19. What is the maximum $\left[Ag^+\right]$ that can exist in 0.20 M $NaBrO_3$?

A. 1.1×10^{-5} M
B. 5.3×10^{-5} M
C. 2.6×10^{-4} M
D. 7.3×10^{-3} M

20. Consider the following equilibrium:

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

Which of the following reagents, when added to the equilibrium system, would cause more $CaCO_3$ to dissolve?

A. $KNO_{3(s)}$
B. $CaCO_{3(s)}$
C. $H_2C_2O_{4(s)}$
D. $Na_2CO_{3(s)}$

21. The conjugate base of $H_2BO_3^-$ is

A. BO_3^{3-}
B. H_3BO_3
C. HBO_3^{2-}
D. $H_3BO_3^-$

22. Which of the following is the **weakest** acid?

A. $HClO$
B. $HClO_2$
C. $HClO_3$
D. $HClO_4$

OVER

23. Consider the following equilibrium for the indicator bromthymol blue:

$$HInd \rightleftarrows H^+ + Ind^-$$

A solution of bromthymol blue is yellow. What should a student do to change the colour of the solution to blue?

A. Add a base to shift the equilibrium left.
B. Add an acid to shift the equilibrium left.
C. Add a base to shift the equilibrium right.
D. Add an acid to shift the equilibrium right.

24. Which of the following is amphiprotic in water?

A. SO_2
B. SO_3^{2-}
C. HSO_3^-
D. H_2SO_3

25. Water acts as a base when it reacts with

A. CN^-
B. NH_3
C. NO_2^-
D. NH_4^+

26. The $\left[OH^-\right]$ in 0.050 M HNO_3 at $25°C$ is

A. 5.0×10^{-16} M
B. 1.0×10^{-14} M
C. 2.0×10^{-13} M
D. 5.0×10^{-2} M

27. Consider the following equilibrium constant expression:

$$K = \frac{\left[H_2S \right]\left[OH^- \right]}{\left[HS^- \right]}$$

This expression represents the

A. K_b for H_2S
B. K_a for H_2S
C. K_b for HS^-
D. K_a for HS^-

28. Which of the following 0.10 M solutions will be yellow in the presence of the indicator chlorophenol red?

A. $AlCl_3$
B. $CaCl_2$
C. K_2CO_3
D. Na_3PO_4

29. Consider the following data:

SOLUTION	INITIAL pH	FINAL pH
1	1.0	4.0
2	2.0	6.0
3	6.0	3.0
4	9.0	3.0

In which solution has the $\left[H_3O^+ \right]$ increased 1000 times ?

A. 1
B. 2
C. 3
D. 4

OVER

30. The pOH of an aqueous solution is equal to

A. $14 + \text{pH}$

B. $\text{pK}_w - \text{pH}$

C. $-\log\ \text{pK}_w$

D. $-\log\left[\text{H}_3\text{O}^+\right]$

31. The reaction of a strong acid with a strong base produces

A. a salt and water.
B. a base and an acid.
C. a metallic oxide and water.
D. a non-metallic oxide and water.

32. The stoichiometric point of a titration is reached when 35.50 mL 0.40 M HBr is added to a 25.00 mL sample of LiOH. The original [LiOH] is

A. 0.014 M
B. 0.024 M
C. 0.28 M
D. 0.57 M

33. What is the pH of a solution prepared by adding 0.50 mol KOH to 1.0 L of 0.30 M HNO_3?

A. 0.20
B. 0.70
C. 13.30
D. 13.80

34. A **basic** buffer solution can be prepared by mixing equal numbers of moles of

A. NH_4Cl and HCl
B. NaCl and NaOH
C. Na_2CO_3 and NaHCO_3
D. NaCH_3COO and CH_3COOH

35. The pH range of 'acid rain' is often

A. 3 to 6
B. 6 to 8
C. 7 to 9
D. 10 to 12

36. Identify the indicator that is blue in a solution when $\left[H_3O^+\right] = 2.5 \times 10^{-6}$.

A. thymol blue
B. thymolphthalein
C. bromthymol blue
D. bromcresol green

37. Consider the following redox reaction:

$$2Cr^{3+}_{(aq)} + 3Cl_{2(aq)} + 7H_2O_{(\ell)} \rightarrow Cr_2O_7{}^{2-}_{(aq)} + 6Cl^-_{(aq)} + 14H^+_{(aq)}$$

The species which loses electrons is

A. Cl_2
B. Cr^{3+}
C. H_2O
D. $Cr_2O_7{}^{2-}$

38. The species which gains electrons in a redox reaction

A. loses mass.
B. is oxidized.
C. is the oxidizing agent.
D. increases in oxidation number.

39. The oxidation number of carbon in CaC_2O_4 is

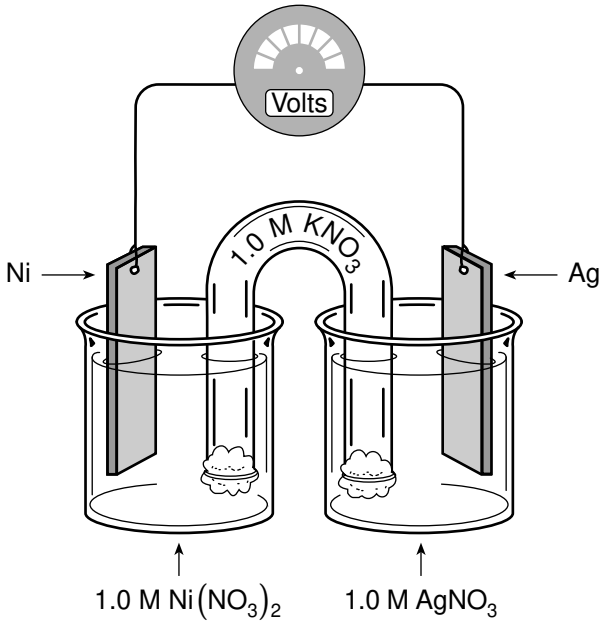
A. +2
B. +3
C. +4
D. +6

40. When MnO_4^- reacts to form Mn^{2+}, the manganese in MnO_4^- is

A. reduced as its oxidation number increases.
B. reduced as its oxidation number decreases.
C. oxidized as its oxidation number increases.
D. oxidized as its oxidation number decreases.

OVER

Use the following diagram to answer questions 41 to 43.



41. The balanced equation for the overall reaction is

A. $Ni^{+}_{(aq)} + Ag_{(s)} \rightarrow Ag^{+}_{(aq)} + Ni_{(s)}$

B. $Ni_{(s)} + Ag^{+}_{(aq)} \rightarrow Ag_{(s)} + Ni^{+}_{(aq)}$

C. $Ni^{2+}_{(aq)} + 2Ag_{(s)} \rightarrow 2Ag^{+}_{(aq)} + Ni_{(s)}$

D. $Ni_{(s)} + 2Ag^{+}_{(aq)} \rightarrow 2Ag_{(s)} + Ni^{2+}_{(aq)}$

42. This redox reaction occurs because

A. $Ag_{(s)}$ is a stronger oxidizing agent than $Ni_{(s)}$

B. $Ag_{(s)}$ is a weaker reducing agent than $Ni_{(s)}$

C. $Ag^{+}_{(aq)}$ is a stronger reducing agent than $Ni^{2+}_{(aq)}$

D. $Ag^{+}_{(aq)}$ is a weaker oxidizing agent than $Ni^{2+}_{(aq)}$

43. The initial cell voltage at 25°C is

A. -1.06 V

B. -0.54 V

C. $+0.54$ V

D. $+1.06$ V

44. In the electrolysis of molten zinc chloride, the half-reaction at the anode is

A. $Cl_2 + 2e^- \rightarrow 2Cl^-$
B. $2Cl^- \rightarrow Cl_2 + 2e^-$
C. $Zn^{2+} + 2e^- \rightarrow Zn$
D. $Zn \rightarrow Zn^{2+} + 2e^-$

45. Corrosion of iron can be prevented by attaching a piece of

A. Mn
B. Cu
C. Pb
D. Sn

46. To plate a nickel coin with copper,

A. the nickel coin must be the cathode.
B. the cathode must be made of copper.
C. the electrons must flow to the anode.
D. the solution must contain nickel ions.

47. Consider the following redox reaction:

$$Co^{2+}_{(aq)} + 2Ag_{(s)} \rightarrow 2Ag^{+}_{(aq)} + Co_{(s)}$$

The reaction is

A. spontaneous and $E°$ is positive.
B. spontaneous and $E°$ is negative.
C. non-spontaneous and $E°$ is positive.
D. non-spontaneous and $E°$ is negative.

48. Which of the following ions can be reduced from an aqueous solution?

A. Ba^{2+}
B. Al^{3+}
C. Sn^{2+}
D. Na^{+}

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

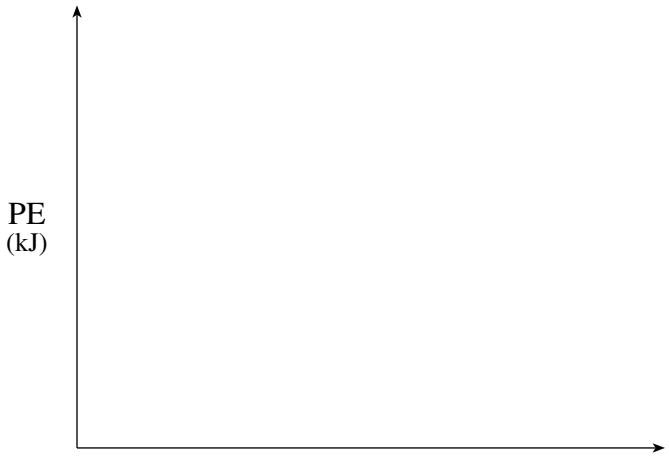
OVER

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. a) On the graph below, draw the potential energy diagram for an exothermic reaction and label the activation energy. **(1 mark)**



b) Define the term *activation energy*. **(1 mark)**

_____

_____

_____

Score for Question 1:

1. _____ (2)

2. Consider the following reaction mechanism:

Step 1: $NO_{(g)} + O_{2(g)} \rightarrow NO_{3(g)}$

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

a) Identify a reaction intermediate. **(1 mark)**

_____

b) Write the equation for the overall reaction. **(1 mark)**

Score for Question 2:

2. _____ (2)

3. Consider the following equilibrium:

$$2CH_{4(g)} \rightleftarrows C_2H_{2(g)} + 3H_{2(g)}$$

A 0.180 mol sample of CH_4 is added to an empty 1.00 L container. At equilibrium, the $[C_2H_2]$ is 0.0800 mol/L. Calculate the equilibrium constant. **(4 marks)**

Score for Question 3:

3. _____ (4)

OVER

4. Consider the following equilibrium:

$$2NOCl_{(g)} \rightleftarrows 2NO_{(g)} + Cl_{2(g)}$$

A chemist places 2.00 mol NOCl in a 1.0 L container. Describe the changes in $[NOCl]$ and $[Cl_2]$ as the system approaches equilibrium. **(1 mark)**

Score for Question 4:

4. _____ (1)

5. A saturated solution of $BaSO_4$ is given to patients needing digestive tract x-rays.

a) Write an equation that represents the solubility equilibrium. **(1 mark)**

b) Calculate the $[Ba^{2+}]$ present in the saturated solution. **(2 marks)**

Score for Question 5:

5. _____ (3)

6. Will a precipitate form when 90.0 mL of 1.00×10^{-2} M $Cu(NO_3)_2$ and 10.0 mL of 1.00×10^{-2} M $NaIO_3$ are mixed? Explain using appropriate calculations.

(3 marks)

Score for Question 6:
6. _____ (3)

OVER

7. Consider the following equilibrium:

$$H_2Se_{(aq)} + HTe^-_{(aq)} \rightleftarrows HSe^-_{(aq)} + H_2Te_{(aq)}$$

The reactants are favoured in this equilibrium.

a) Identify the stronger acid. _____ **(1 mark)**

b) Identify the weaker base. _____ **(1 mark)**

Score for Question 7:

7. _____ (2)

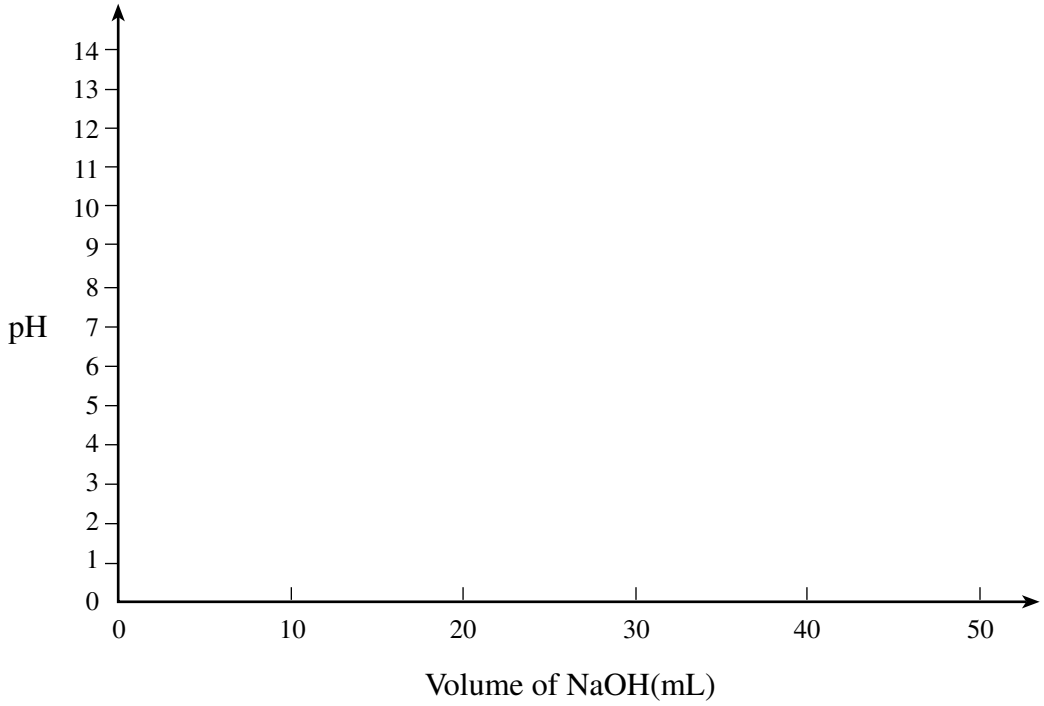
8. The hydrogen carbonate ion can act as an acid or a base. Use calculations to determine if a solution containing 0.10 M hydrogen carbonate ion is acidic or basic. **(3 marks)**

Score for Question 8:

8. _____ (3)

9. In a titration, 25.00 mL of 0.10 M HCl was neutralized by slowly adding 50.00 mL of 0.10 M NaOH.

a) Sketch the titration curve for the reaction and label:
– the initial pH of the HCl,
– the volume of NaOH required to neutralize the HCl, and
– the pH at the equivalence point. **(4 marks)**



b) Select a suitable indicator for this titration. **(1 mark)**

Score for Question 9:
9. _____ (5)

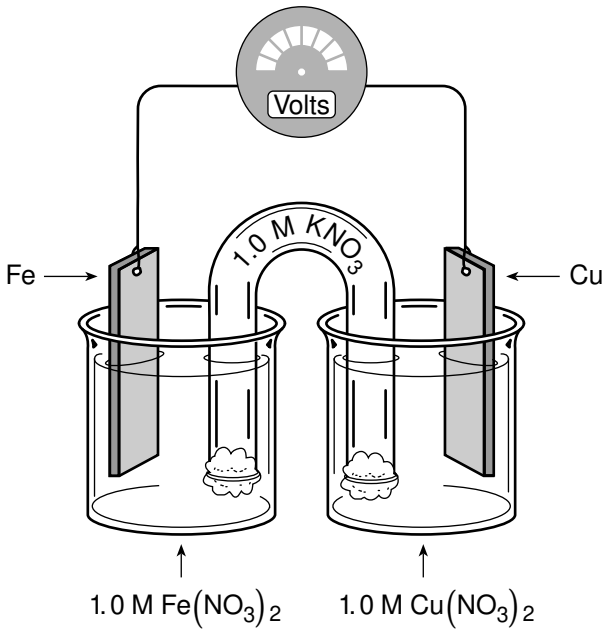
OVER

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

$$TcO_4^- + MnO_4^{2-} \rightarrow Tc + MnO_4^- \qquad \text{(acidic)}$$

Score for Question 10:
10. _____ (4)

11. Consider the following electrochemical cell:



a) Clearly indicate on the diagram above, the direction of electron flow through the wire. **(1 mark)**

b) Write the equation for the half-reaction taking place at the Fe electrode. **(1 mark)**

c) What is the initial cell voltage? **(1 mark)**

Score for Question 11:
11. _____ (3)

END OF EXAMINATION