INSERT STUDENT I.D. NUMBER (PEN)

STICKER IN THIS SPACE

JANUARY 1999

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 and on the **back** cover of this booklet. **Under no circumstance is your name or identification, other than your Student I.D. Number, to appear on this booklet.**

2. Ensure that in addition to this examination booklet, you have a **Data Booklet** and an **Examination Response Form**. Follow the directions on the front of the Response Form.

3. **Disqualification** from the examination will result if you bring books, paper, notes or unauthorized electronic devices into the examination room.

4. All multiple-choice answers must be entered on the Response Form using an **HB pencil**. Multiple-choice answers entered in this examination booklet will **not** be marked.

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

6. 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.

7. At the end of the examination, place your Response Form inside the front cover of this booklet and return the booklet and your Response Form to the supervisor.

CHEMISTRY 12 PROVINCIAL EXAMINATION

		Value	Suggested Time
1. This examination consists of **two** parts:			
PART A:	48 multiple-choice questions	48	70
PART B:	9 written-response questions	32	50
	Total:	**80 marks**	**120 minutes**

2. Aside from an approved calculator, electronic devices, including dictionaries and pagers, are **not** permitted in the examination room.

3. 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.

4. **A calculator is essential for the Chemistry 12 Provincial Examination.** The calculator must be a hand-held device designed primarily for mathematical computations involving logarithmic and trigonometric functions and may also include graphing functions. Computers, calculators with a QWERTY keyboard, and electronic writing pads will not be allowed. Students must not bring any external support devices such as manuals, printed or electronic cards, printers, memory expansion chips, or external keyboards. Students may have more than one calculator available during the examination, but calculators may not be shared. Communication between calculators is prohibited and calculators must not have the ability to either transmit or receive electronic signals. In addition to an approved calculator, students will be allowed to use rulers, compasses, and protractors during the examination.

5. The time allotted for this examination is **two hours**.

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 Response Form provided. Using an HB pencil, completely fill in the circle that has the letter corresponding to your answer.

1. Consider the reaction:

$$Ca_{(s)} + 2H_2O_{(\ell)} \rightarrow Ca(OH)_{2(aq)} + H_{2(g)}$$

At a certain temperature, $2.50\,g$ Ca reacts completely in 30.0 seconds.
The rate of consumption of Ca is

A. 0.00208 mol/min
B. 0.0833 mol/min
C. 0.125 mol/min
D. 5.00 mol/min

2. The minimum amount of energy required to overcome the energy barrier in a chemical reaction is the

A. heat of reaction.
B. activation energy.
C. KE of the reactants.
D. enthalpy of the products.

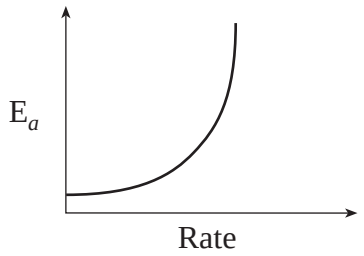
3. An activated complex is a chemical species that is

A. stable and has low PE.
B. stable and has high PE.
C. unstable and has low PE.
D. unstable and has high PE.

OVER

4. A certain reaction is able to proceed by various mechanisms. Each mechanism has a different E_a and results in a different overall rate. Which of the following best describes the relationship between the E_a values and the rates?

A.



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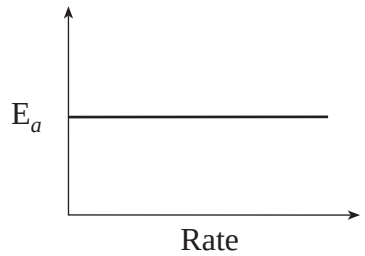

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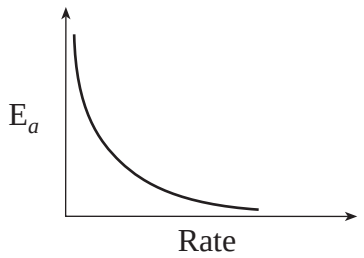

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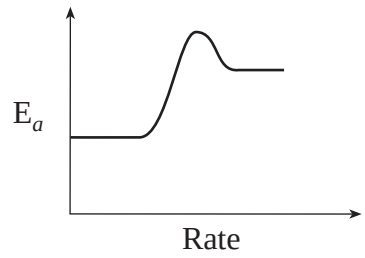
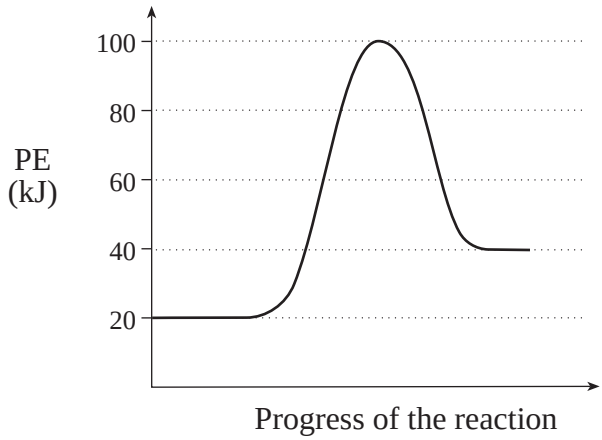


5. Consider the following PE diagram:



The forward reaction can be described as

	ΔH (kJ)	ACTIVATION ENERGY (kJ)	TYPE OF REACTION
A.	+20	80	endothermic
B.	+20	60	exothermic
C.	–20	80	exothermic
D.	–20	100	endothermic

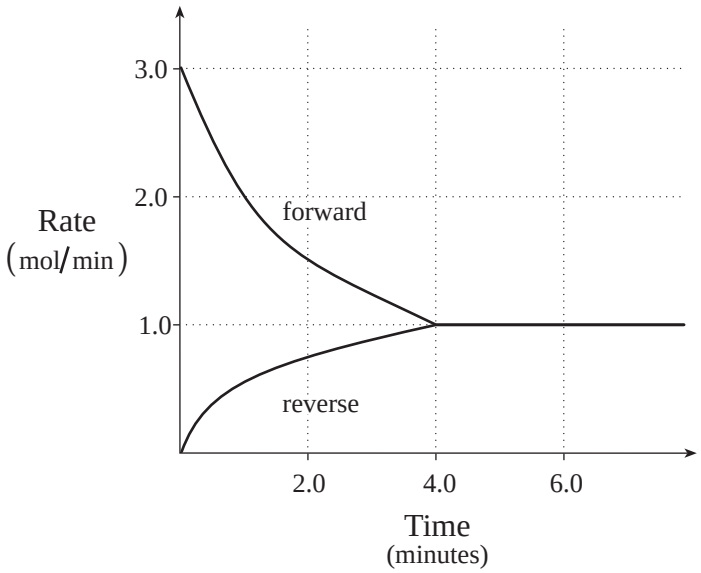
6. Consider the following reaction mechanism:

Step 1	$2NO + H_2 \rightarrow N_2 + H_2O_2$
Step 2	$H_2O_2 + H_2 \rightarrow 2H_2O$

In this reaction, H_2 is a

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

7. Consider the following graph:



When equilibrium is reached, the rate of the forward reaction is

A. $0.00\,mol/min$
B. $0.25\,mol/min$
C. $1.0\,mol/min$
D. $3.0\,mol/min$

OVER

8. Consider the following equilibrium:

$$2NO_{2(g)} \rightleftarrows N_2O_{4(g)} + \text{energy}$$

The equilibrium will shift to the left as a result of

A. adding a catalyst.
B. increasing the volume.
C. removing some N_2O_4.
D. decreasing the temperature.

9. Ethene, C_2H_4, can be produced in the following industrial system:

$$C_2H_{6(g)} + \text{energy} \rightleftarrows C_2H_{4(g)} + H_{2(g)}$$

The conditions that are necessary to maximize the equilibrium yield of C_2H_4 are

A. low temperature and low pressure.
B. low temperature and high pressure.
C. high temperature and low pressure.
D. high temperature and high pressure.

10. Consider the following equilibrium:

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

The volume of the equilibrium system is increased and a new equilibrium is established. Compared to the rates in the original equilibrium, which of the following describes the rates of the forward and reverse reactions in the new equilibrium?

	FORWARD RATE	REVERSE RATE
A.	decreased	decreased
B.	increased	increased
C.	decreased	increased
D.	remained constant	remained constant

11. Consider the following equilibrium:

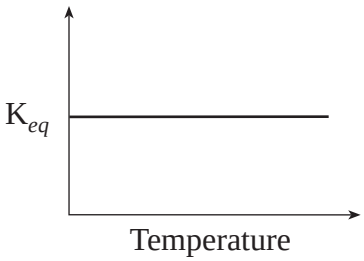
$$N_{2(g)} + 3H_{2(g)} \rightleftarrows 2NH_{3(g)} + \text{energy}$$

Certain conditions provide less than 10% yield of NH_3 at equilibrium. Which of the following describes this equilibrium?

	K_{eq}	EQUILIBRIUM POSITION
A.	large	favours products
B.	small	favours products
C.	large	favours reactants
D.	small	favours reactants

12. Which of the following best describes the relationship between K_{eq} and temperature for an endothermic reaction?

A.



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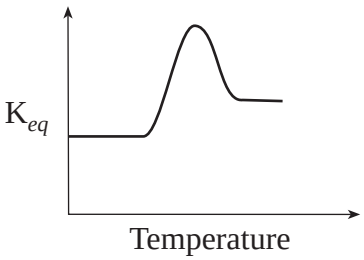

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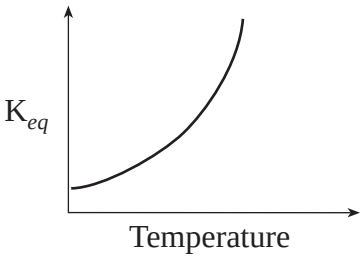
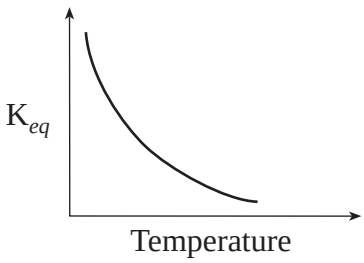


D.



OVER

13. Consider the following equilibrium:

$$CO_{(g)} + 2H_{2(g)} \rightleftarrows CH_3OH_{(g)} \qquad K_{eq} = 12.0$$

At equilibrium, a $1.00\,L$ flask contains $0.020\,mol$ CO and $0.35\,mol$ H_2.
What is the concentration of CH_3OH at equilibrium?

A. 2.0×10^{-4} mol/L
B. 5.8×10^{-4} mol/L
C. 2.9×10^{-2} mol/L
D. 8.4×10^{-2} mol/L

14. Which of the following units could be used to describe solubility?

A. g/s
B. g/L
C. M/L
D. mol/s

15. Consider the following anions:

	ANION
I.	$10.0\,mL$ of $0.20\,M$ Cl^-
II.	$10.0\,mL$ of $0.20\,M$ OH^-
III.	$10.0\,mL$ of $0.20\,M$ SO_3^{2-}

When $10.0\,mL$ of $0.20\,M$ $Pb(NO_3)_2$ are added to each of the above, precipitates form in

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

16. When equal volumes of $0.20\,\text{M}\ CuSO_4$ and $0.20\,\text{M}\ Li_2S$ are combined, the complete ionic equation is

A. $Cu^{2+}_{(aq)} + S^{2-}_{(aq)} \rightarrow CuS_{(s)}$

B. $CuSO_{4(aq)} + Li_2S_{(aq)} \rightarrow CuS_{(s)} + Li_2SO_{4(aq)}$

C. $Cu^{2+}_{(aq)} + SO_4{}^{2-}_{(aq)} + 2Li^{+}_{(aq)} + S^{2-}_{(aq)} \rightarrow Li_2SO_{4(aq)} + CuS_{(s)}$

D. $Cu^{2+}_{(aq)} + SO_4{}^{2-}_{(aq)} + 2Li^{+}_{(aq)} + S^{2-}_{(aq)} \rightarrow CuS_{(s)} + 2Li^{+}_{(aq)} + SO_4{}^{2-}_{(aq)}$

17. The K_{sp} expression for a saturated solution of Ag_2CO_3 is

A. $K_{sp} = \left[Ag_2{}^{+}\right]\left[CO_3{}^{2-}\right]$

B. $K_{sp} = \left[Ag^{+}\right]^2\left[CO_3{}^{2-}\right]$

C. $K_{sp} = \left[2Ag^{+}\right]\left[CO_3{}^{2-}\right]$

D. $K_{sp} = \left[2Ag^{+}\right]^2\left[CO_3{}^{2-}\right]$

18. The solubility of FeF_2 is $8.4\times10^{-3}\,\text{M}$. The K_{sp} value is

A. 5.9×10^{-7}

B. 2.4×10^{-6}

C. 7.1×10^{-5}

D. 8.4×10^{-3}

19. If the Trial Ion Product for $AgBrO_3$ is calculated to be 1.0×10^{-7}, then

A. a precipitate forms because the Trial Ion Product > K_{sp}

B. a precipitate forms because the Trial Ion Product < K_{sp}

C. no precipitate forms because the Trial Ion Product > K_{sp}

D. no precipitate forms because the Trial Ion Product < K_{sp}

OVER

20. The least soluble salt in water is

A. CaS
B. $CaSO_4$
C. CaC_2O_4
D. $Ca(NO_3)_2$

21. Consider the following acid-base equilibrium:

$$HCO_3^- + H_2O \rightleftarrows H_2CO_3 + OH^-$$

In the reaction above, the Brönsted-Lowry acids are

A. H_2O and OH^-
B. HCO_3^- and OH^-
C. H_2O and H_2CO_3
D. HCO_3^- and H_2CO_3

22. Consider the following solubility equilibrium:

$$Mg(OH)_{2(s)} \rightleftarrows Mg^{2+}_{(aq)} + 2OH^-_{(aq)}$$

A compound that could be added to cause this equilibrium to shift to the right is

A. Na_2O
B. NH_4Cl
C. $Sr(OH)_2$
D. $Mg(OH)_2$

23. The solution with the lowest electrical conductivity is

A. $0.10\,M\ H_2S$
B. $0.10\,M\ HNO_2$
C. $0.10\,M\ H_2SO_3$
D. $0.10\,M\ NH_4Cl$

24. The solution with the lowest pH is

A. $1.0\,\text{M}$ HF
B. $1.0\,\text{M}$ HCN
C. $1.0\,\text{M}$ HCOOH
D. $1.0\,\text{M}$ CH_3COOH

25. As the $\left[H_3O^+\right]$ in a solution decreases, the $\left[OH^-\right]$

A. increases and the pH increases.
B. increases and the pH decreases.
C. decreases and the pH increases.
D. decreases and the pH decreases.

26. The value of pK_w at $25°\,C$ is

A. 1.0×10^{-14}
B. 1.0×10^{-7}
C. 7.00
D. 14.00

27. Consider the following equilibrium:

$$2H_2O + \text{energy} \rightleftarrows H_3O^+ + OH^-$$

In pure water at a temperature of $50°\,C$,

A. $pH < 7$

B. $pH + pOH = 14$

C. $K_w = 1.0 \times 10^{-14}$

D. $\left[OH^-\right] < 1.0 \times 10^{-7}$

OVER

28. What is the pOH of 2.5 M NaOH?

A. -0.40

B. 0.0032

C. 0.40

D. 13.60

29. A $0.010\,\text{M}$ acid solution has a pH of 2.00. The acid could be

A. HNO_3
B. H_2SO_3
C. HCOOH
D. CH_3COOH

30. Which of the following salts dissolves to produce a basic aqueous solution?

A. LiF

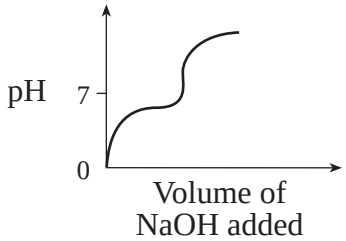
B. $KClO_4$

C. $NaHSO_3$

D. NH_4NO_3

31. Which titration curve represents the titration of HCl with NaOH?

A.



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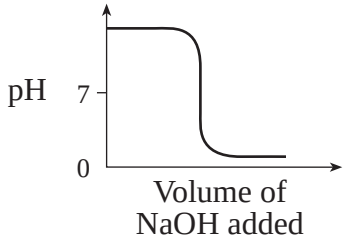
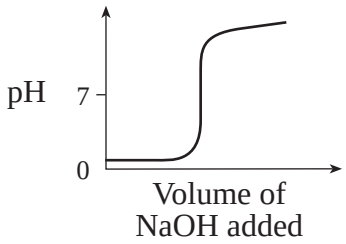


C.



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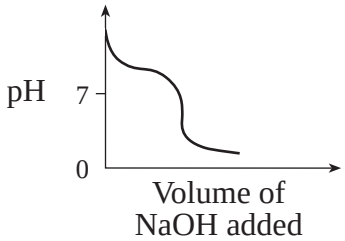


32. A buffer solution can be formed by dissolving equal moles of

A. HF and NaF
B. HCl and NaOH
C. KBr and Na_3PO_4
D. CH_3COOH and NaCl

33. Which of the following gases is a contributor to the formation of acid rain?

A. H_2
B. O_3
C. SO_2
D. NH_3

OVER

34. During a titration, an indicator is found to change colour when the $\left[H_3O^+\right] = 1 \times 10^{-6}$ M. Identify the indicator.

A. methyl violet
B. alizarin yellow
C. phenolphthalein
D. chlorophenol red

35. Consider the following:

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

The term amphiprotic can be used to describe

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

36. Calculate the $\left[H_3O^+\right]$ in a solution prepared by mixing $25.0\,\text{mL}$ of $1.0\,\text{M}$ HCl with $50.0\,\text{mL}$ of $0.50\,\text{M}$ KOH.

A. 1.0 M

B. 0.50 M

C. 0.25 M

D. 1.0×10^{-7} M

37. Consider the following redox reaction:

$$2MnO_4^- + 3ClO_3^- + H_2O \rightarrow 3ClO_4^- + 2MnO_2 + 2OH^-$$

The reducing agent is

A. H_2O
B. ClO_3^-
C. MnO_2
D. MnO_4^-

38. Consider the following reaction that occurs in a breathalyzer:

$$2Cr_2O_7^{2-}{}_{(aq)} + 16H^+{}_{(aq)} + 3C_2H_5OH_{(g)} \rightarrow 4Cr^{3+}{}_{(aq)} + 11H_2O_{(l)} + 3CH_3COOH_{(aq)}$$

Which atom undergoes an increase in oxidation number?

A. carbon
B. oxygen
C. hydrogen
D. chromium

39. Which of the following is the strongest reducing agent?

A. Al
B. Cu
C. Zn
D. Mg

40. Which of the following reactions is spontaneous at standard conditions?

A. $Pb + Cu^{2+} \rightarrow Cu + Pb^{2+}$
B. $H_2 + Mg^{2+} \rightarrow Mg + 2H^+$
C. $Br_2 + 2Cl^- \rightarrow Cl_2 + 2Br^-$
D. $2Ag + Cu^{2+} \rightarrow Cu + 2Ag^+$

OVER

41. Consider the following redox reaction:

$$3ClO_2^- \rightarrow 2ClO_3^- + Cl^- \qquad (\text{basic})$$

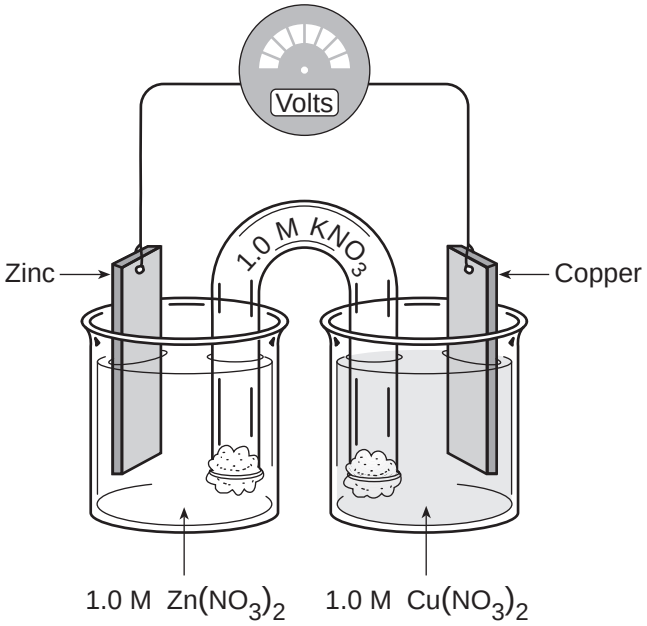
The reduction half-reaction that occurs is

A. $ClO_2^- + 2H_2O + 4e^- \rightarrow Cl^- + 4OH^-$
B. $ClO_2^- + 2H_2O \rightarrow Cl^- + 4OH^- + 4e^-$
C. $ClO_2^- + 2OH^- + 2e^- \rightarrow ClO_3^- + H_2O$
D. $ClO_2^- + 2OH^- \rightarrow ClO_3^- + H_2O + 2e^-$

42. Vanadium metal, V, reacts spontaneously with Cd^{2+}, but not with Ti^{2+}. Based on these results, the order of oxidizing agents, from strongest to weakest, is

A. Cd^{2+}, V^{2+}, Ti^{2+}
B. V^{2+}, Ti^{2+}, Cd^{2+}
C. Ti^{2+}, Cd^{2+}, V^{2+}
D. Ti^{2+}, V^{2+}, Cd^{2+}

43. Consider the following electrochemical cell:



In this operating electrochemical cell,

A. electrons flow toward the Cu and the Cu^{2+} ions migrate toward the Zn.
B. electrons flow toward the Cu and the Zn^{2+} ions migrate toward the Cu.
C. electrons flow toward the Zn and the Cu^{2+} ions migrate toward the Zn.
D. electrons flow toward the Zn and the Zn^{2+} ions migrate toward the Cu.

44. Which of the following affects the potentials of electrochemical cells?

I.	species used as oxidizing agent
II.	temperature
III.	concentration of reactants

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

OVER

45. In the rusting of iron, the reduction reaction that occurs is

A. $Fe \rightarrow Fe^{2+} + 2e^-$

B. $Fe^{2+} + 2e^- \rightarrow Fe$

C. $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$

D. $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

46. During a cathodic protection, the sacrificial anode

A. accepts electrons from the protected metal.
B. reacts spontaneously with the protected metal.
C. oxidizes more readily than the protected metal.
D. causes the protected metal to become an anode.

47. During the electrolysis of an aqueous solution of KI, what substance is formed at the cathode?

A. iodine
B. oxygen
C. hydrogen
D. potassium

48. When electroplating an iron medallion with nickel,

A. the medallion is an anode.

B. the cathode is pure nickel.

C. the solution contains Ni^{2+}.

D. the anode reaction is $Ni^{2+} + 2e^- \rightarrow Ni$

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

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. Consider the following reaction mechanism:

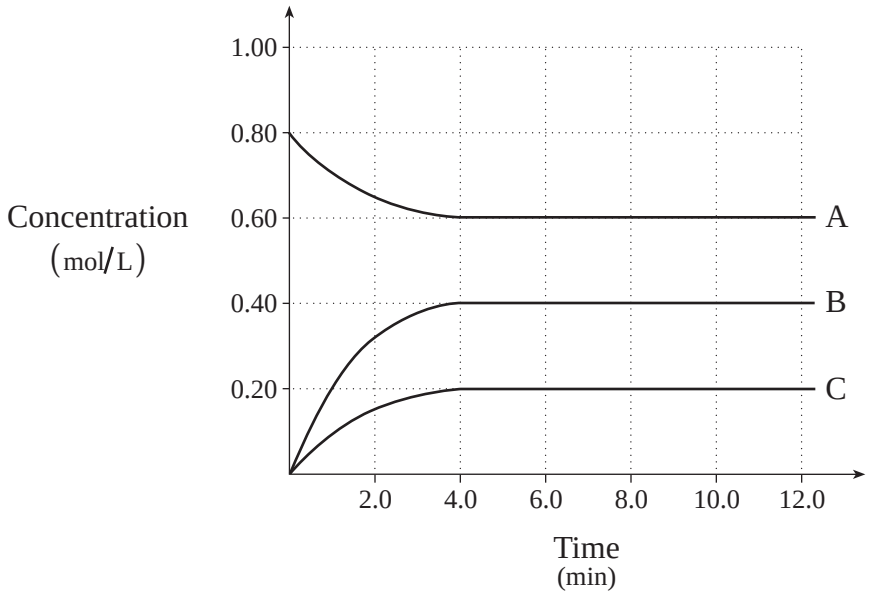
Step 1	?
Step 2	$H_2 + Cl \rightarrow HCl + H$
Step 3	$H + Cl_2 \rightarrow HCl + Cl$
Step 4	$Cl + Cl \rightarrow Cl_2$
Overall	$H_2 + Cl_2 \rightarrow 2HCl$

a) Write the equation for Step 1. **(2 marks)**

b) Identify the reaction intermediate(s). **(1 mark)**

OVER

2. Consider the following diagram for a chemical system containing three substances represented by A, B and C:



a) What feature of the graph indicates that the system reaches equilibrium? **(1 mark)**

b) Write a balanced equation for the equilibrium reaction. **(2 marks)**

c) Calculate K_{eq} at equilibrium. **(2 marks)**

3. In an experiment to determine the solubility of barium fluoride, $500.0\,\text{mL}$ of the saturated solution was heated in an evaporating dish to remove the water. The evaporating dish and residue were heated two more times, to ensure all the water had been driven off.

I.	Volume of saturated solution of BaF_2	$500.0\,\text{mL}$
II.	Mass of evaporating dish	$72.540\,\text{g}$
III.	Mass of evaporating dish and BaF_2 after first heating	$73.500\,\text{g}$
IV.	Mass of evaporating dish and BaF_2 after second heating	$72.855\,\text{g}$
V.	Mass of evaporating dish and BaF_2 after third heating	$72.855\,\text{g}$

Using the data above, calculate the K_{sp} for BaF_2. **(4 marks)**

OVER

4. Consider the salt sodium oxalate, $Na_2C_2O_4$.

a) Write the dissociation equation for sodium oxalate. **(1 mark)**

b) A $1.0\,M$ solution of sodium oxalate turns pink when a few drops of the indicator phenolphthalein are added. Write a hydrolysis equation and explain why this salt causes the indicator to change colour. **(2 marks)**

c) Calculate the equilibrium constant for the hydrolysis in b). **(1 mark)**

5. Calculate the pH of $0.50\,\mathrm{M}\ H_3BO_3$. **(4 marks)**

OVER

6. A $25.0\,\text{mL}$ sample of $Sr(OH)_2$ is titrated with a standardized solution of HCl to the equivalence point.

a) Write the formula equation for the neutralization. **(1 mark)**

b) Write the net ionic equation for the neutralization. **(1 mark)**

c) What is meant by the term “standardized” solution? **(1 mark)**

d) Define *equivalence point*. **(1 mark)**

7. Balance the following redox reaction in acidic solution:

$$RuO_4 + P \rightarrow Ru(OH)_2^{2+} + H_3PO_3 \qquad (\text{acid})$$ **(3 marks)**

OVER

8. A technician tests the concentration of methanol, CH_3OH, in diluted windshield washer fluid using a redox titration. A $25.00\,mL$ sample is titrated with $14.50\,mL$ of $0.0200\,M$ $KMnO_4$. Determine the concentration of methanol in the sample given the following redox reaction:

$$6H^+ + 2MnO_4^- + 5CH_3OH \rightarrow 5CH_2O + 2Mn^{2+} + 8H_2O$$ **(3 marks)**

9. An electrolytic cell can be used to plate a copper penny with a silver coating. Sketch a diagram of the electrolytic cell. Label the cathode and show the direction of electron flow. **(2 marks)**

END OF EXAMINATION