

**JANUARY 1998**

## **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 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 <b>two</b> parts:		
PART A: 48 multiple-choice questions	48	70
PART B: 10 written-response questions	32	50
	<b>Total: 80 marks</b>	<b>120 minutes</b>

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 Brønsted-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. Computers, calculators with a QWERTY keyboard, and electronic writing pads will not be allowed. Students must not bring any external devices to support calculators such as manuals, printed or electronic cards, printers, memory expansion chips or cards, or external keyboards. Students may have more than one calculator available during the examination. Calculators may not be shared, and communication between calculators is prohibited during the examination. 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**.

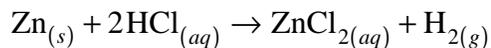
**PART A: MULTIPLE CHOICE**

**Value: 48 marks**

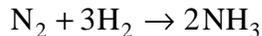
**Suggested Time: 70 minutes**

**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. Which of the following properties could be used to measure the rate of the following reaction taking place in an open container?

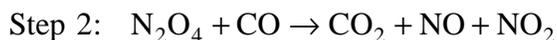
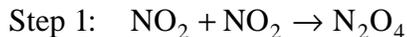


- A. mass of Zn
  - B. solubility of HCl
  - C. concentration of  $\text{Cl}^-$
  - D. colour of the solution
2. Consider the following reaction:



The rate of formation of  $\text{NH}_3$  is 3.0 mL/min. The rate of consumption of  $\text{H}_2$  is

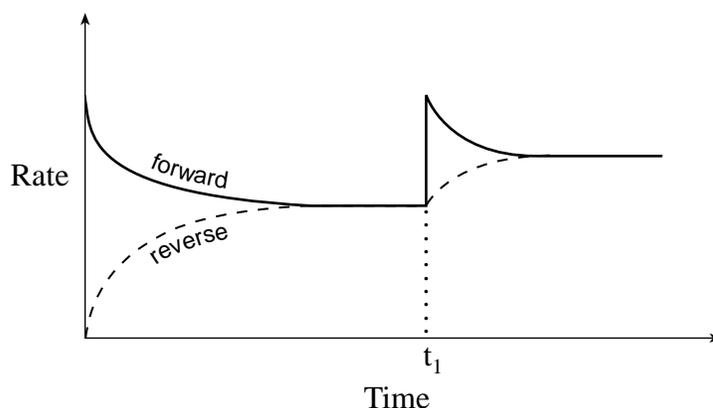
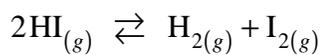
- A. 1.5 mL/min
  - B. 2.0 mL/min
  - C. 4.5 mL/min
  - D. 9.0 mL/min
3. Consider the following reaction mechanism:



In the overall reaction,  $\text{N}_2\text{O}_4$  is a

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

4. Consider the rate diagram below for the following reaction:



Which of the following occurs at time  $t_1$  ?

- A. addition of  $\text{H}_2$
- B. addition of HI
- C. addition of a catalyst
- D. a decrease in volume

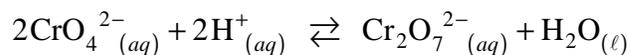
5. Chemical equilibrium is said to be dynamic because

- A. the reaction proceeds quickly.
- B. the mass of the reactants is decreasing.
- C. the macroscopic properties are constant.
- D. both forward and reverse reactions are occurring.

6. Which equation has the largest value of  $K_{eq}$  ?

- A.  $\text{N}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{NO}_{(g)} \quad \Delta H = 21 \text{ kJ}$
- B.  $\text{C}_2\text{H}_{6(g)} \rightleftharpoons 2\text{C}_{(g)} + 3\text{H}_{2(g)} \quad \Delta H = 83 \text{ kJ}$
- C.  $\text{H}_{2(g)} + \frac{1}{2}\text{O}_{2(g)} \rightleftharpoons \text{H}_2\text{O}_{(g)} \quad \Delta H = -240 \text{ kJ}$
- D.  $\text{Ca}_{(s)} + 2\text{H}_2\text{O}_{(\ell)} \rightleftharpoons \text{Ca}(\text{OH})_{2(aq)} + \text{H}_{2(g)} \quad \Delta H = -240 \text{ kJ}$

7. Given the following system:



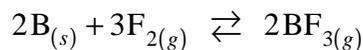
Which of the following chemicals, when added to the above system at equilibrium, would result in a decrease in  $[\text{CrO}_4^{2-}]$ ?

- A. NaOH
- B.  $\text{HNO}_3$
- C.  $\text{Na}_2\text{CrO}_4$
- D.  $\text{Na}_2\text{Cr}_2\text{O}_7$

8. Addition of a catalyst to an equilibrium system

- A. increases the value of  $K_{eq}$ .
- B. increases the yield of products.
- C. has no effect on the rates of reaction.
- D. increases the rate of formation of both reactants and products.

9. Consider the following reaction:

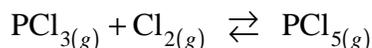


The equilibrium expression is

- A.  $K_{eq} = \frac{[2\text{BF}_3]}{[3\text{F}_2]}$
- B.  $K_{eq} = \frac{[\text{F}_2]^3}{[\text{BF}_3]^2}$
- C.  $K_{eq} = \frac{[\text{BF}_3]^2}{[\text{F}_2]^3}$
- D.  $K_{eq} = \frac{[\text{BF}_3]^2}{[\text{B}]^2[\text{F}_2]^3}$

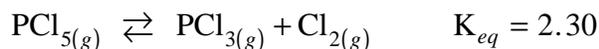
10. The value of  $K_{eq}$  can be changed by
- adding a catalyst.
  - changing the temperature.
  - changing the reactant concentration.
  - changing the volume of the container.

11. Consider the following equilibrium:



When 0.40 mol of  $\text{PCl}_3$  and 0.40 mol of  $\text{Cl}_2$  are placed in a 1.00 L container and allowed to reach equilibrium, 0.244 mol of  $\text{PCl}_5$  are present. From this information, the value of  $K_{eq}$  is

- 0.10
  - 0.30
  - 3.3
  - 10
12. Consider the following equilibrium:



A 1.0 L container is filled with 0.05 mol  $\text{PCl}_5$ , 1.0 mol  $\text{PCl}_3$ , and 1.0 mol  $\text{Cl}_2$ . The system proceeds to the

- left because  $K_{eq} > K_{eq}$
  - left because  $K_{eq} < K_{eq}$
  - right because  $K_{eq} > K_{eq}$
  - right because  $K_{eq} < K_{eq}$
13. When solid  $\text{AgBr}$  is added to a saturated solution of  $\text{AgBr}$ , the reaction rates can be described as:

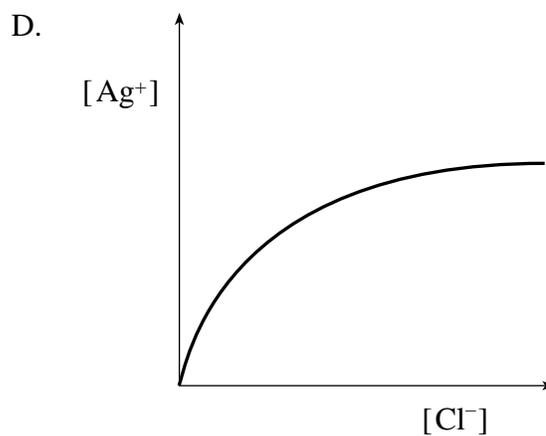
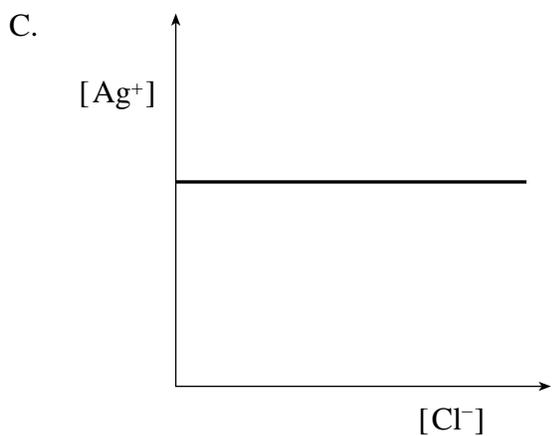
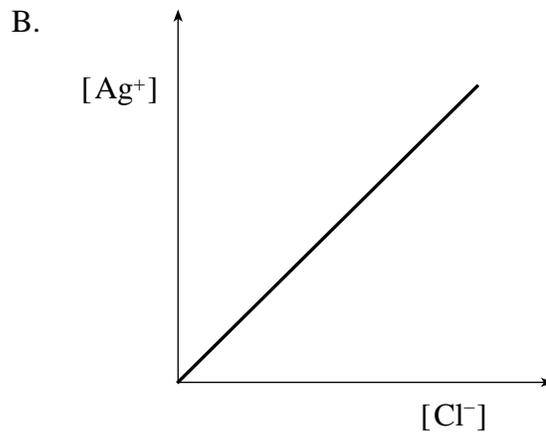
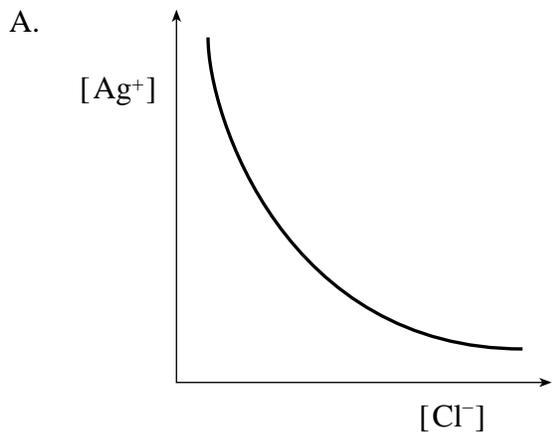
	RATE OF DISSOLVING	RATE OF CRYSTALLIZATION
A.	increases	increases
B.	increases	decreases
C.	decreases	increases
D.	increases	no change

14. Which of the following units can be used to represent solubility?
- A. g
  - B. mol
  - C. mol/L
  - D. mL/s
15. When equal volumes of 0.2 M  $\text{K}_2\text{CO}_3$  and 0.2 M  $\text{Na}_3\text{PO}_4$  are mixed,
- A. no precipitate will form.
  - B. a precipitate of  $\text{K}_3\text{PO}_4$  will form.
  - C. a precipitate of  $\text{Na}_2\text{CO}_3$  will form.
  - D. a precipitate of both  $\text{K}_3\text{PO}_4$  and  $\text{Na}_2\text{CO}_3$  will form.
16. A 3.0 L solution of  $\text{NiCl}_2$  is found to have a chloride concentration of 0.60 M. The concentration of nickel(II) ions in this solution is
- A. 0.30 M
  - B. 0.60 M
  - C. 0.90 M
  - D. 1.2 M
17. Which of the following causes a precipitate to form when  $\text{Sr}^{2+}_{(aq)}$  is added but not when  $\text{Zn}^{2+}_{(aq)}$  is added?
- A.  $\text{S}^{2-}$
  - B.  $\text{Cl}^-$
  - C.  $\text{SO}_4^{2-}$
  - D.  $\text{CO}_3^{2-}$
18. The solubility of  $\text{PbS}$  is  $2.9 \times 10^{-14}$  M. What is the value of  $K_{sp}$  for  $\text{PbS}$ ?
- A.  $8.4 \times 10^{-28}$
  - B.  $2.9 \times 10^{-14}$
  - C.  $5.8 \times 10^{-14}$
  - D.  $1.7 \times 10^{-7}$

19. Consider the following equation:



Which of the following graphs represents the relationship between  $[\text{Ag}^+]$  and  $[\text{Cl}^-]$  in this system at a constant temperature?



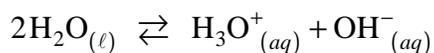
20. The acid found in vinegar will

- A. taste bitter.
- B. feel slippery.
- C. change litmus to blue.
- D. react with Mg to produce  $\text{H}_2$

21. In which of the following equilibrium systems is  $\text{HCO}_3^-$  acting as a Brønsted-Lowry base?
- A.  $\text{HCO}_3^- \rightleftharpoons \text{H}^+ + \text{CO}_3^{2-}$   
 B.  $\text{HCO}_3^- + \text{HS}^- \rightleftharpoons \text{H}_2\text{S} + \text{CO}_3^{2-}$   
 C.  $\text{HCO}_3^- + \text{H}_2\text{S} \rightleftharpoons \text{H}_2\text{CO}_3 + \text{HS}^-$   
 D.  $\text{HCO}_3^- + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{CO}_3^{2-}$
22. The conjugate acid of  $\text{H}_2\text{O}$  is
- A.  $\text{O}^{2-}$   
 B.  $\text{OH}^-$   
 C.  $\text{H}_3\text{O}^+$   
 D.  $\text{H}_2\text{O}_2$
23. The strongest acid that can exist in an aqueous solution is
- A.  $\text{NH}_2^-$   
 B.  $\text{H}_3\text{O}^+$   
 C.  $\text{HNO}_2$   
 D.  $\text{HClO}_4$
24. Which of the following is possible for an acid?

	ACID STRENGTH	CONCENTRATION	pH
A.	strong	0.01 M	2.0
B.	weak	0.01 M	1.0
C.	strong	3 M	5.5
D.	weak	3 M	-0.5

25. Consider the following equilibrium:



A small amount of HCl is added to water and equilibrium is reestablished. When comparing the new equilibrium with the original equilibrium,

- A.  $[\text{H}_3\text{O}^+]$  and pH both decreased.
- B.  $[\text{H}_3\text{O}^+]$  and pH both increased.
- C.  $[\text{H}_3\text{O}^+]$  increased and pH decreased.
- D.  $[\text{H}_3\text{O}^+]$  decreased and pH increased.

26. The  $[\text{H}_3\text{O}^+]$  in 100.0 mL of 0.015 M KOH is

- A.  $6.7 \times 10^{-13}$
- B.  $6.7 \times 10^{-12}$
- C.  $1.5 \times 10^{-3}$
- D.  $1.5 \times 10^{-2}$

27. At any temperature,  $\text{pK}_w$  is defined as

- A.  $\text{pK}_w = \text{pH} + \text{pOH}$
- B.  $\text{pK}_w = \text{pH} - \text{pOH}$
- C.  $\text{pK}_w = \text{pH} \times \text{pOH}$
- D.  $\text{pK}_w = \frac{\text{pH}}{\text{pOH}}$

28. The  $[\text{OH}^-]$  of a solution with pH 5.75 is

- A.  $5.6 \times 10^{-9}$  M
- B.  $1.8 \times 10^{-6}$  M
- C.  $7.6 \times 10^{-1}$  M
- D.  $9.2 \times 10^{-1}$  M

29. The value of  $K_b$  for  $\text{HPO}_4^{2-}$  is

- A.  $2.2 \times 10^{-13}$
- B.  $6.2 \times 10^{-8}$
- C.  $1.6 \times 10^{-7}$
- D.  $4.5 \times 10^{-2}$

30. Which of the following 0.10 M solutions is basic?

- A. LiCl
- B.  $\text{K}_3\text{PO}_4$
- C.  $\text{NaClO}_4$
- D.  $\text{NH}_4\text{NO}_3$

31. Consider the following equilibrium for the indicator HInd at its transition point:



When a small amount of base is added, the equilibrium shifts to the

- A. left and the  $[\text{HInd}] > [\text{Ind}^-]$
- B. left and the  $[\text{HInd}] < [\text{Ind}^-]$
- C. right and the  $[\text{HInd}] > [\text{Ind}^-]$
- D. right and the  $[\text{HInd}] < [\text{Ind}^-]$

32. The approximate  $K_a$  value for the indicator thymolphthalein is

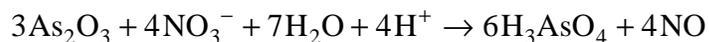
- A.  $1 \times 10^{-10}$
- B.  $1 \times 10^{-4}$
- C. 4
- D. 10

33. What volume of 0.100 M NaOH is needed to completely neutralize 25.0 mL of 0.100 M  $\text{H}_2\text{SO}_4$ ?
- A. 12.5 mL
  - B. 25.0 mL
  - C. 50.0 mL
  - D. 75.0 mL
34. When 0.10 mol of NaOH is added to 1.00 L of 0.30 M HCl, the pH of the resulting solution is
- A. 0.52
  - B. 0.70
  - C. 1.00
  - D. 13.30
35. Which of the following could be used to form a buffer solution?
- A. HBr and NaOH
  - B. HCl and  $\text{NH}_4\text{Cl}$
  - C.  $\text{HNO}_3$  and  $\text{NaNO}_3$
  - D.  $\text{H}_2\text{CO}_3$  and  $\text{NaHCO}_3$
36. Normal rain has a pH of approximately 6 as a result of dissolved
- A. oxygen.
  - B. carbon dioxide.
  - C. sulphur dioxide.
  - D. nitrogen dioxide.
37. Which of the following represents a redox reaction?
- A.  $\text{H}_2\text{CO}_3 \rightarrow \text{H}_2\text{O} + \text{CO}_2$
  - B.  $\text{CuS} + \text{H}_2 \rightarrow \text{H}_2\text{S} + \text{Cu}$
  - C.  $\text{AgNO}_3 + \text{NaCl} \rightarrow \text{AgCl} + \text{NaNO}_3$
  - D.  $2\text{HCl} + \text{Na}_2\text{SO}_3 \rightarrow 2\text{NaCl} + \text{H}_2\text{O} + \text{SO}_2$

38. The oxidation number of carbon in  $\text{C}_2\text{O}_4^{2-}$  is

- A. +3
- B. +4
- C. +5
- D. +6

39. Consider the following redox reaction:



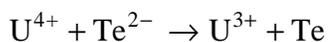
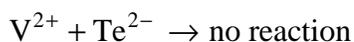
The oxidizing agent is

- A.  $\text{H}^+$
- B.  $\text{H}_2\text{O}$
- C.  $\text{NO}_3^-$
- D.  $\text{As}_2\text{O}_3$

40. When  $\text{W}_2\text{O}_5$  is converted to  $\text{WO}_2$  in a redox reaction, the W has been

- A. reduced since its oxidation number has increased.
- B. reduced since its oxidation number has decreased.
- C. oxidized since its oxidation number has increased.
- D. oxidized since its oxidation number has decreased.

41. A student investigating redox reactions recorded the following results:



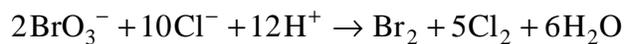
Based on these results, the strengths of the oxidizing agents, arranged from strongest to weakest, are

- A.  $\text{V}^{2+}$ ,  $\text{Te}$ ,  $\text{U}^{4+}$
- B.  $\text{U}^{4+}$ ,  $\text{Te}$ ,  $\text{V}^{2+}$
- C.  $\text{U}^{3+}$ ,  $\text{Te}^{2-}$ ,  $\text{V}^{2+}$
- D.  $\text{V}^{2+}$ ,  $\text{Te}^{2-}$ ,  $\text{U}^{3+}$

42. A spontaneous redox reaction occurs when  $\text{Sn}^{2+}$  is mixed with

- A.  $\text{I}_2$
- B.  $\text{Cu}$
- C.  $\text{H}_2\text{S}$
- D.  $\text{Ag}_2\text{S}$

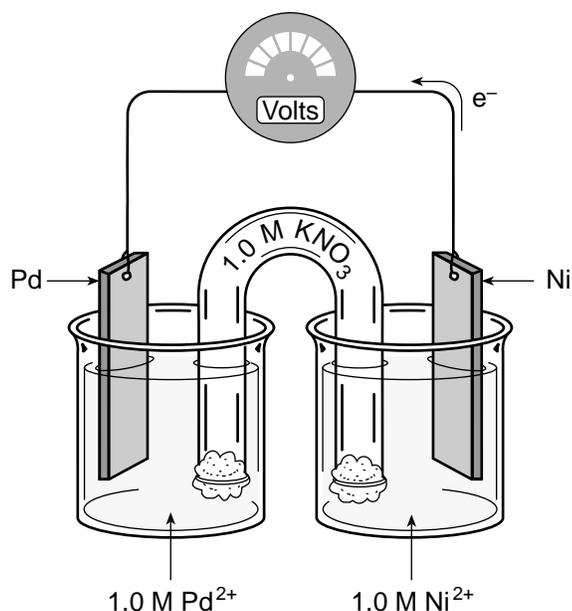
43. Consider the redox reaction below:



The oxidation half-reaction involved in this reaction is

- A.  $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$
- B.  $2\text{H}^+ \rightarrow \text{H}_2 + 2\text{e}^-$
- C.  $\text{BrO}_3^- + 6\text{H}^+ + 5\text{e}^- \rightarrow \frac{1}{2}\text{Br}_2 + 3\text{H}_2\text{O}$
- D.  $\text{BrO}_3^- + 6\text{H}^+ \rightarrow \frac{1}{2}\text{Br}_2 + 3\text{H}_2\text{O} + 5\text{e}^-$

Use the following diagram to answer questions 44, 45 and 46.



44. As the cell operates, the electrons flow from the nickel electrode to the palladium electrode. The reaction occurring at the anode is
- A.  $\text{Pd} \rightarrow \text{Pd}^{2+} + 2\text{e}^{-}$
  - B.  $\text{Ni} \rightarrow \text{Ni}^{2+} + 2\text{e}^{-}$
  - C.  $\text{Pd}^{2+} + 2\text{e}^{-} \rightarrow \text{Pd}$
  - D.  $\text{Ni}^{2+} + 2\text{e}^{-} \rightarrow \text{Ni}$
45. As the cell operates,
- A. both the  $\text{K}^{+}$  and the  $\text{NO}_3^{-}$  migrate into the nickel half-cell.
  - B. both the  $\text{K}^{+}$  and the  $\text{NO}_3^{-}$  migrate into the palladium half-cell.
  - C. the  $\text{K}^{+}$  migrates into the nickel half-cell and the  $\text{NO}_3^{-}$  migrates into the palladium half-cell.
  - D. the  $\text{K}^{+}$  migrates into the palladium half-cell and the  $\text{NO}_3^{-}$  migrates into the nickel half-cell.
46. The initial cell voltage is 1.21 V. The reduction potential of  $\text{Pd}^{2+}$  is
- A.  $-1.21 \text{ V}$
  - B.  $-0.95 \text{ V}$
  - C.  $+0.95 \text{ V}$
  - D.  $+1.21 \text{ V}$

47. Consider the following chemicals:

I	water
II	oxygen gas
III	nitrogen gas

At 25°C, a piece of iron rusts in the presence of

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

48. During the electrolysis of 1.0 M  $\text{Na}_2\text{SO}_4$ , the reaction at the cathode is

- A.  $\text{Na}^+ + \text{e}^- \rightarrow \text{Na}$
- B.  $2\text{SO}_4^{2-} \rightarrow \text{S}_2\text{O}_8^{2-} + 2\text{e}^-$
- C.  $2\text{H}_2\text{O} \rightarrow \text{O}_2 + 4\text{H}^+ + 4\text{e}^-$
- D.  $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2 + 2\text{OH}^-$

**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**

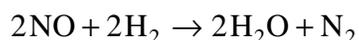
**INSTRUCTIONS:** You will be expected to communicate your knowledge and understanding of chemical principles in a clear and logical manner.

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 overall reaction:

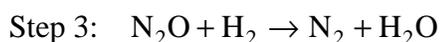
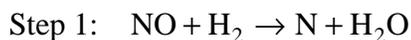


- a) Explain why the reaction is likely to involve more than one step. **(1 mark)**

---

---

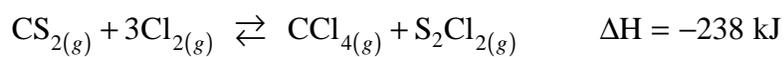
- b) A proposed mechanism for the reaction is:



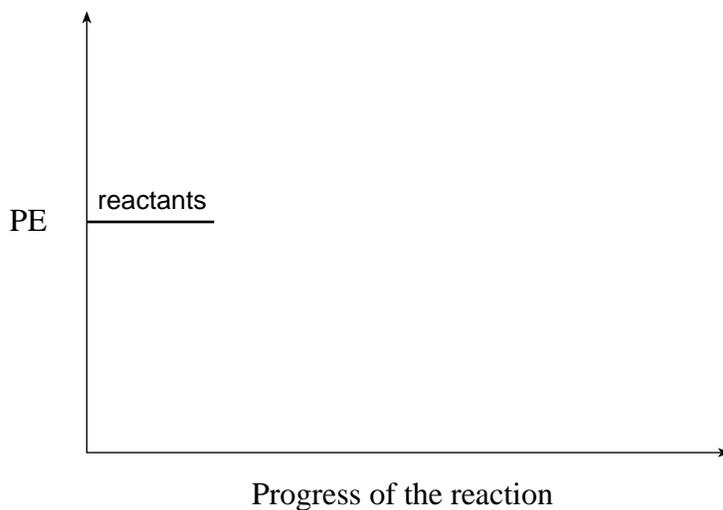
- i) Write the equation for Step 2. **(2 marks)**

- ii) Identify all reaction intermediates. **(1 mark)**

2. Consider the following equilibrium:



a) Sketch a potential energy diagram for the reaction above and label  $\Delta H$ . **(2 marks)**



b) Some  $\text{CS}_2$  is added and equilibrium is then reestablished. State the direction of the equilibrium shift and the resulting change in  $[\text{Cl}_2]$ . **(1 mark)**

---

---

---

c) The temperature is decreased and equilibrium is then reestablished. What will the effect be on the value of  $K_{eq}$ ? **(1 mark)**

---

3. A 100.00 mL sample of a saturated solution of  $\text{Ca}(\text{OH})_2$  is evaporated to dryness. The mass of the solid residue is 0.125 g. Calculate the solubility product of  $\text{Ca}(\text{OH})_2$ .

**(4 marks)**

4. Write the net ionic equation representing the reaction that occurs when equal volumes of 0.20 M  $\text{H}_2\text{SO}_4$  and 0.20 M  $\text{Ba}(\text{NO}_3)_2$  are mixed together. **(2 marks)**

5. Define the term *strong Brønsted-Lowry acid*. **(2 marks)**

---

---

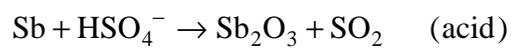
---

---

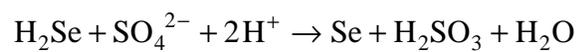
6. Nicotinic acid,  $\text{HC}_6\text{H}_4\text{NO}_2$ , is a weak acid found in vitamin B.  
Calculate the pH of 0.010 M  $\text{HC}_6\text{H}_4\text{NO}_2$  ( $K_a = 1.4 \times 10^{-5}$ ). **(4 marks)**
7. A solution of NaOH is used to neutralize separate solutions of HF and HBr.
- a) Write the formula equation for the neutralization of HF. **(1 mark)**
- b) Write the net ionic equation for the neutralization of HBr. **(1 mark)**
- c) One of the neutralization reactions above produces a salt that undergoes hydrolysis.  
Identify the salt and write the net ionic equation for the hydrolysis reaction. **(2 marks)**

8. Balance the following redox reaction:

**(3 marks)**



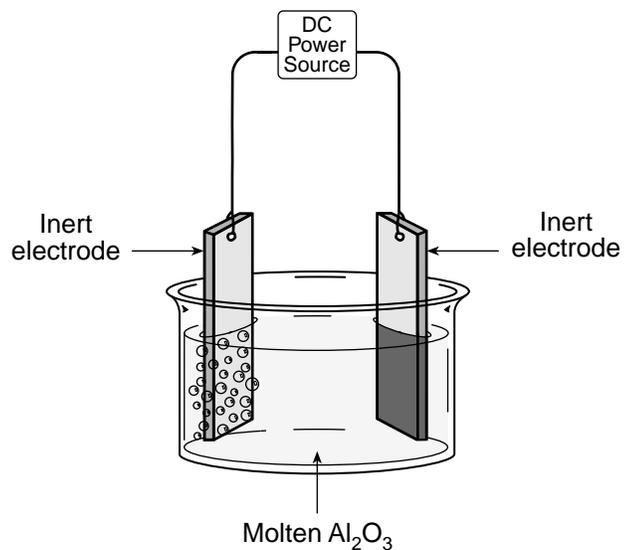
9. Consider the following redox reaction:



Calculate the  $E^\circ$  for the reaction above.

**(2 marks)**

10. Consider the following electrolytic cell used for the electrolysis of molten aluminum oxide.



a) Write the equation for the half-reaction taking place at the anode. **(1 mark)**

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

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

**END OF EXAMINATION**