

**AUGUST 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 <b>two</b> parts:		
PART A: 48 multiple-choice questions	48	70
PART B: 11 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 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**

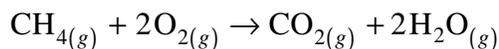
**Suggested Time: 70 minutes**

**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. At room temperature, which of the following reactions is fastest?

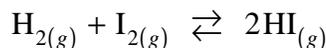
- A.  $2\text{H}_{2(g)} + \text{O}_{2(g)} \rightarrow 2\text{H}_2\text{O}_{(g)}$
- B.  $\text{Pb}^{2+}_{(aq)} + 2\text{I}^{-}_{(aq)} \rightarrow \text{PbI}_{2(s)}$
- C.  $4\text{Fe}_{(s)} + 3\text{O}_{2(g)} \rightarrow 2\text{Fe}_2\text{O}_{3(s)}$
- D.  $\text{Cu}_{(s)} + 2\text{Ag}^{+}_{(aq)} \rightarrow \text{Cu}^{2+}_{(aq)} + 2\text{Ag}_{(s)}$

2. Consider the following reaction:



At a certain temperature, 1.0 mol  $\text{CH}_4$  is consumed in 4.0 minutes.  
The rate of production of  $\text{H}_2\text{O}$  is

- A. 0.25 mol/min
  - B. 0.50 mol/min
  - C. 2.0 mol/min
  - D. 8.0 mol/min
3. Consider the following reaction in a closed system:



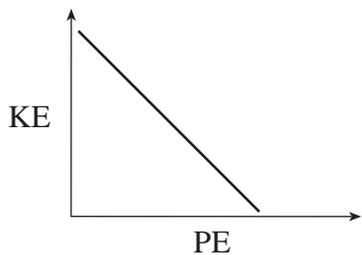
Which of the following will cause the rate of the forward reaction to decrease?

- A.  $\text{H}_2$  is added.
- B. A catalyst is added.
- C. The volume is increased.
- D. The temperature is increased.

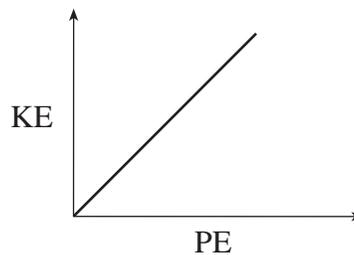
**OVER**

4. The changes in PE and KE, as reactant molecules approach each other, can be represented by

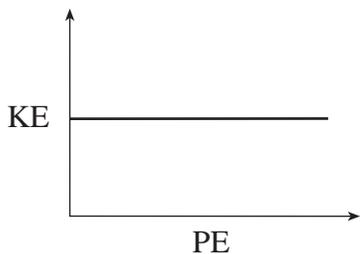
A.



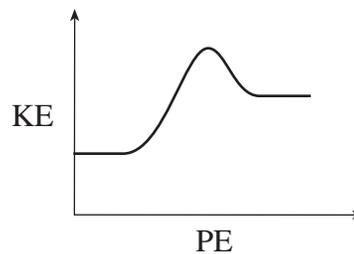
B.



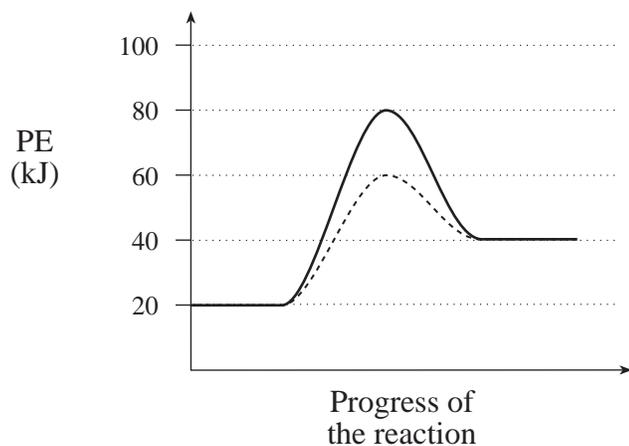
C.



D.



5. Consider the following PE diagram:



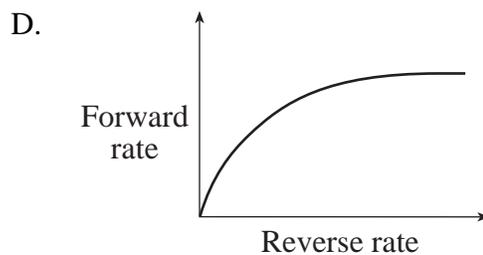
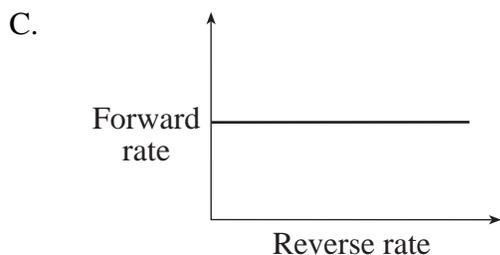
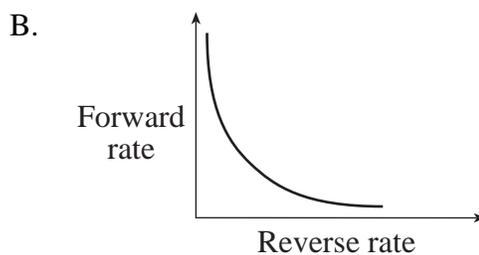
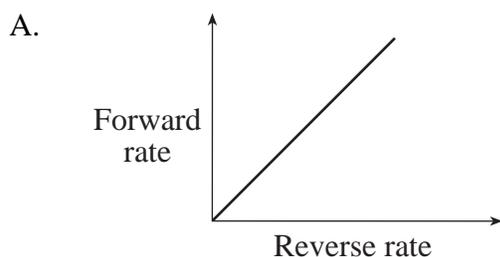
Which of the following describes this reaction?

	$\Delta H$ (kJ)	ACTIVATION ENERGY (kJ)	REACTION
A.	-20	40	catalyzed
B.	-20	60	catalyzed
C.	+20	40	uncatalyzed
D.	+20	60	uncatalyzed

6. A chemical reaction that gives off energy is

- A. exothermic and  $\Delta H$  is positive.
- B. exothermic and  $\Delta H$  is negative.
- C. endothermic and  $\Delta H$  is positive.
- D. endothermic and  $\Delta H$  is negative.

7. At different conditions, the relationship between the forward and reverse rates of reaction in an equilibrium system can be represented by



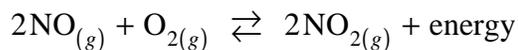
8. Consider the following equilibrium:



Which of the following will cause the equilibrium to shift to the left?

- A. adding  $\text{H}_2\text{O}_{(g)}$
- B. removing some  $\text{NO}_{(g)}$
- C. increasing the volume
- D. decreasing the temperature

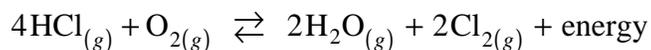
9. Consider the following equilibrium:



When the volume of the container is increased, the equilibrium shifts to the

- A. left and  $K_{eq}$  decreases.
- B. right and  $K_{eq}$  increases.
- C. left and  $K_{eq}$  remains constant.
- D. right and  $K_{eq}$  remains constant.

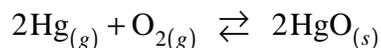
10. Consider the following equilibrium:



The temperature of the equilibrium system is increased and a new equilibrium is established. The rates of the forward and reverse reactions for the new equilibrium compared to the original equilibrium have

	FORWARD RATE	REVERSE RATE
A.	increased	increased
B.	decreased	not changed
C.	decreased	increased
D.	not changed	increased

11. Consider the following reaction:



The equilibrium constant expression for the reaction is

A.  $K_{eq} = \frac{1}{[\text{Hg}]^2[\text{O}_2]}$

B.  $K_{eq} = [\text{Hg}]^2[\text{O}_2]$

C.  $K_{eq} = \frac{[\text{HgO}]^2}{[\text{Hg}]^2[\text{O}_2]}$

D.  $K_{eq} = \frac{[2\text{HgO}]}{[2\text{Hg}][\text{O}_2]}$

12. The value of  $K_{eq}$  changes when

- A. a catalyst is added.
- B. the temperature changes.
- C. the surface area changes.
- D. the concentration of reactants changes.

13. Consider the following equilibrium:



A 1.00 L flask contains 0.0200 mol  $\text{PCl}_5$ , 0.0500 mol  $\text{PCl}_3$  and 0.0500 mol  $\text{Cl}_2$  at equilibrium. The value of  $K_{eq}$  is

- A. 0.125
- B. 2.50
- C. 5.00
- D. 8.00

14. Consider the following solutes:

I.	$\text{K}_3\text{PO}_4$
II.	$\text{C}_2\text{H}_5\text{OH}$
III.	$\text{C}_{12}\text{H}_{22}\text{O}_{11}$
IV.	$\text{KCH}_3\text{COO}$

Which of the solutes above form only molecular aqueous solutions?

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

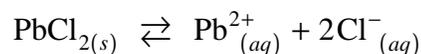
15. At a certain temperature,  $7.0 \times 10^{-4}$  mol  $\text{MgSO}_4$  is present in 100.0 mL of solution. The concentration of the  $\text{Mg}^{2+}$  in this solution is

- A.  $7.0 \times 10^{-5}$  M
- B.  $7.0 \times 10^{-4}$  M
- C.  $7.0 \times 10^{-3}$  M
- D.  $7.0 \times 10^{-6}$  M

16. When equal volumes of 0.20 M  $\text{SrBr}_2$  and 0.20 M  $\text{AgNO}_3$  are combined,

- A. no precipitate forms.
- B. a precipitate of only  $\text{AgBr}$  forms.
- C. a precipitate of only  $\text{Sr}(\text{NO}_3)_2$  forms.
- D. precipitates of both  $\text{AgBr}$  and  $\text{Sr}(\text{NO}_3)_2$  form.

17. Consider the following solubility equilibrium:



A student adds  $\text{NaCl}_{(s)}$  to a saturated solution of  $\text{PbCl}_2$ . When equilibrium is reestablished, how have the concentrations changed from the original equilibrium?

- A.  $[\text{Pb}^{2+}]$  and  $[\text{Cl}^{-}]$  both increased.
- B.  $[\text{Pb}^{2+}]$  and  $[\text{Cl}^{-}]$  both decreased.
- C.  $[\text{Pb}^{2+}]$  decreased and  $[\text{Cl}^{-}]$  increased.
- D.  $[\text{Pb}^{2+}]$  increased and  $[\text{Cl}^{-}]$  decreased.

18. Solid  $\text{Ag}_2\text{CrO}_4$  is added to water to form a saturated solution. The  $K_{sp}$  value can be calculated by

- A.  $K_{sp} = [\text{CrO}_4^{2-}]^2$
- B.  $K_{sp} = [\text{CrO}_4^{2-}]^3$
- C.  $K_{sp} = \frac{[\text{CrO}_4^{2-}]^3}{2}$
- D.  $K_{sp} = 4[\text{CrO}_4^{2-}]^3$

19. Consider the following solubility equilibrium:

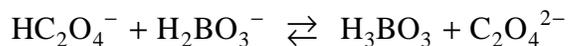


Which of the following will result in an increase of  $[\text{Ba}^{2+}]$  ?

- A. adding water
- B. adding  $\text{BaS}_{(s)}$
- C. adding  $\text{BaSO}_{3(s)}$
- D. adding  $\text{Na}_2\text{SO}_{3(s)}$

20. When equal volumes of 0.20 M  $\text{Ca}(\text{NO}_3)_2$  and 0.20 M  $\text{Na}_2\text{SO}_4$  are combined,
- A. a precipitate forms because Trial Ion Product  $> K_{sp}$
  - B. a precipitate forms because Trial Ion Product  $< K_{sp}$
  - C. no precipitate forms because Trial Ion Product  $> K_{sp}$
  - D. no precipitate forms because Trial Ion Product  $< K_{sp}$
21. Solid  $\text{NaBrO}_3$  is added to a 0.010 M  $\text{Ag}^+$  solution. What is the  $[\text{BrO}_3^-]$  when a precipitate first forms?
- A.  $2.8 \times 10^{-9}$  M
  - B.  $5.3 \times 10^{-7}$  M
  - C.  $5.3 \times 10^{-3}$  M
  - D.  $1.0 \times 10^{-2}$  M
22. An Arrhenius acid is defined as a chemical species that
- A. is a proton donor.
  - B. is a proton acceptor.
  - C. produces hydrogen ions in solution.
  - D. produces hydroxide ions in solution.

23. Consider the acid-base equilibrium system:



Identify the Brønsted-Lowry bases in this equilibrium.

- A.  $\text{H}_2\text{BO}_3^-$  and  $\text{H}_3\text{BO}_3$
- B.  $\text{HC}_2\text{O}_4^-$  and  $\text{H}_3\text{BO}_3$
- C.  $\text{HC}_2\text{O}_4^-$  and  $\text{C}_2\text{O}_4^{2-}$
- D.  $\text{H}_2\text{BO}_3^-$  and  $\text{C}_2\text{O}_4^{2-}$

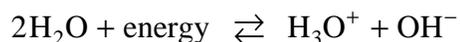
24. An equation representing the reaction of a weak acid with water is

- A.  $\text{HCl} + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{Cl}^-$
- B.  $\text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4^+ + \text{OH}^-$
- C.  $\text{HCO}_3^- + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3 + \text{OH}^-$
- D.  $\text{HCOOH} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{HCOO}^-$

25. The equilibrium expression for the ion product constant of water is

- A.  $K_w = \frac{[\text{H}_3\text{O}^+][\text{OH}^-]}{[\text{H}_2\text{O}]}$
- B.  $K_w = [\text{H}_3\text{O}^+]^2[\text{O}_2]$
- C.  $K_w = [\text{H}_3\text{O}^+][\text{OH}^-]$
- D.  $K_w = [\text{H}_3\text{O}^+]^2[\text{O}^{2-}]$

26. Consider the following equilibrium:



Which of the following describes the result of decreasing the temperature?

	$[\text{H}_3\text{O}^+]$	$[\text{OH}^-]$	$K_w$
A.	increases	increases	increases
B.	decreases	increases	decreases
C.	increases	decreases	no change
D.	decreases	decreases	decreases

27. In an acidic solution at 25°C,

- A.  $[\text{H}_3\text{O}^+] < [\text{OH}^-]$  and  $\text{pH} > 7$
- B.  $[\text{H}_3\text{O}^+] < [\text{OH}^-]$  and  $\text{pH} < 7$
- C.  $[\text{H}_3\text{O}^+] > [\text{OH}^-]$  and  $\text{pH} > 7$
- D.  $[\text{H}_3\text{O}^+] > [\text{OH}^-]$  and  $\text{pH} < 7$

28. The pH of a solution changes from 3.00 to 6.00. By what factor does the  $[\text{H}_3\text{O}^+]$  change?

- A. 2
- B. 3
- C. 100
- D. 1000

29. The  $K_a$  expression for the hydrogen sulphite ion,  $\text{HSO}_3^-$ , is

A. 
$$K_a = \frac{[\text{SO}_3^{2-}][\text{H}_3\text{O}^+]}{[\text{HSO}_3^-]}$$

B. 
$$K_a = \frac{[\text{H}_2\text{SO}_3][\text{H}_3\text{O}^+]}{[\text{HSO}_3^-]}$$

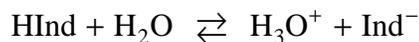
C. 
$$K_a = \frac{[\text{SO}_3^{2-}][\text{H}_3\text{O}^+]}{[\text{H}_2\text{SO}_3]}$$

D. 
$$K_a = \frac{[\text{SO}_3^{2-}][\text{H}_3\text{O}^+]}{[\text{HSO}_3^-][\text{H}_2\text{O}]}$$

30. The  $[\text{OH}^-]$  in a solution of pH 3.00 is

- A.  $1.0 \times 10^{-11}$  M
- B.  $1.0 \times 10^{-9}$  M
- C.  $1.0 \times 10^{-6}$  M
- D.  $1.0 \times 10^{-3}$  M

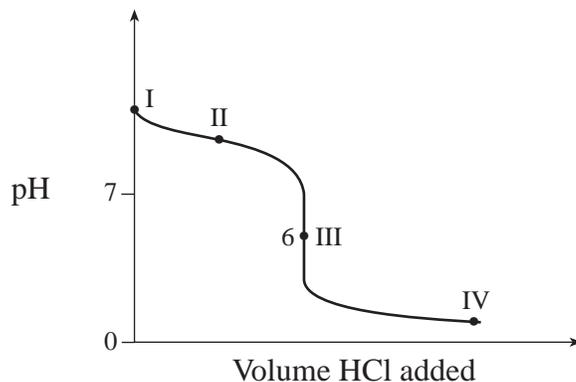
31. Consider the following equilibrium for an indicator:



Which two species must be of two different colours in order to be used as an indicator?

- A. HInd and H<sub>2</sub>O
  - B. HInd and Ind<sup>-</sup>
  - C. H<sub>3</sub>O<sup>+</sup> and Ind<sup>-</sup>
  - D. HInd and H<sub>3</sub>O<sup>+</sup>
32. Which of the following indicators is yellow at a pH of 10.0?
- A. methyl red
  - B. phenol red
  - C. thymol blue
  - D. methyl violet
33. A sample containing  $1.20 \times 10^{-2}$  mol HCl is completely neutralized by 100.0 mL of Sr(OH)<sub>2</sub>. What is the [Sr(OH)<sub>2</sub>]?
- A.  $6.00 \times 10^{-3}$  M
  - B.  $6.00 \times 10^{-2}$  M
  - C.  $1.20 \times 10^{-1}$  M
  - D.  $2.4 \times 10^{-1}$  M
34. Which of the following titrations will have the highest pH at the equivalence point?
- A. HBr with NH<sub>3</sub>
  - B. HNO<sub>2</sub> with KOH
  - C. HCl with Na<sub>2</sub>CO<sub>3</sub>
  - D. HNO<sub>3</sub> with NaOH

35. Consider the following graph for the titration of 0.1M  $\text{NH}_3$  with 0.1M HCl:



A buffer solution is present at point

- A. I
- B. II
- C. III
- D. IV

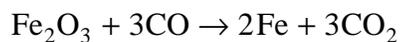
36. Which of the following solutions would require the greatest volume of 1.0 M NaOH for complete neutralization?

- A. 10.0 mL of 1.0 M HCl
- B. 10.0 mL of 2.0 M  $\text{H}_2\text{SO}_4$
- C. 10.0 mL of 3.0 M  $\text{H}_3\text{PO}_4$
- D. 10.0 mL of 4.0 M  $\text{H}_2\text{C}_2\text{O}_4$

37. Which of the following is **not** a redox reaction?

- A.  $\text{Cu} + \text{Br}_2 \rightarrow \text{CuBr}_2$
- B.  $\text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{H}_2$
- C.  $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$
- D.  $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$

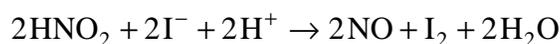
38. The following reaction represents the process used to produce iron from iron(III) oxide:



What is the reducing agent in this process?

- A. Fe
- B. CO
- C.  $\text{CO}_2$
- D.  $\text{Fe}_2\text{O}_3$

39. Consider the following reaction:



The oxidation number for each nitrogen atom

- A. increases by 1
- B. increases by 2
- C. decreases by 1
- D. decreases by 2

40. Which of the following reactions is spontaneous?

- A.  $2\text{I}^- + \text{Ag} \rightarrow \text{Ag}^+ + \text{I}_2$
- B.  $\text{Co}^{2+} + \text{Cu} \rightarrow \text{Co} + \text{Cu}^{2+}$
- C.  $\text{Cu}^{2+} + \text{Pb} \rightarrow \text{Pb}^{2+} + \text{Cu}$
- D.  $\text{Ni}^{2+} + 2\text{Ag} \rightarrow 2\text{Ag}^+ + \text{Ni}$

41. Consider the following redox reaction for a lead-acid storage cell:

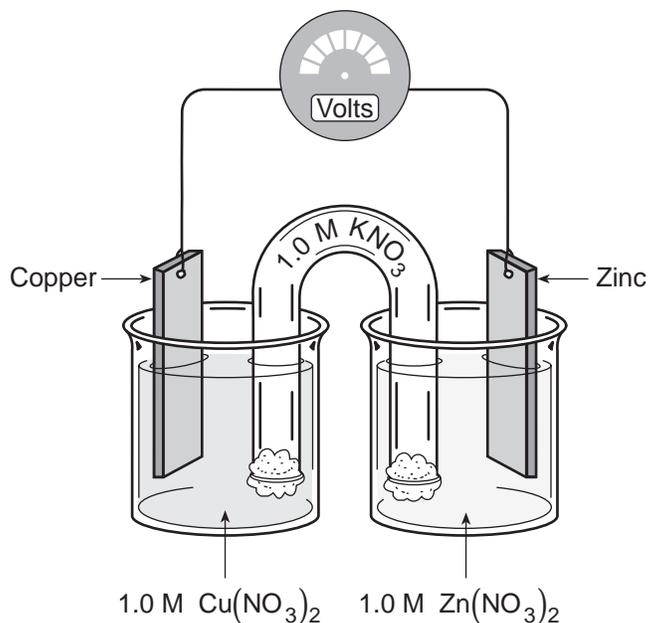


The balanced, reduction half-reaction is

- A.  $\text{Pb} + \text{SO}_4^{2-} \rightarrow \text{PbSO}_4 + 2\text{e}^-$
- B.  $\text{Pb} + 2\text{H}^+ + \text{SO}_4^{2-} \rightarrow \text{PbSO}_4 + \text{H}_2\text{O} + 2\text{e}^-$
- C.  $\text{PbO}_2 + 4\text{H}^+ + \text{SO}_4^{2-} + 2\text{e}^- \rightarrow \text{PbSO}_4 + 2\text{H}_2\text{O}$
- D.  $\text{PbO}_2 + \text{SO}_4^{2-} + 4\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{PbSO}_4 + 4\text{OH}^-$

**OVER**

Use the following diagram to answer questions 42 and 43.



42. Which of the following statements apply to this electrochemical cell?

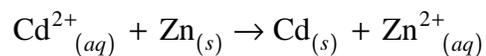
I.	Electrons flow through the wire toward the copper electrode.
II.	The copper electrode increases in mass.
III.	Anions move toward the Zn half cell.

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

43. At equilibrium, the voltage of the cell above is

- A. -1.10 V
- B. 0.00 V
- C. +0.42 V
- D. +1.10 V

44. Consider the following reaction:



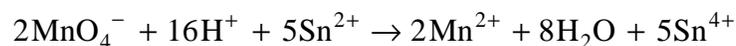
The potential for the reaction is +0.36 V. What is the reduction potential for the cadmium ion?

- A. -1.12 V
- B. -0.40 V
- C. +0.40 V
- D. +1.12 V

45. Which of the following involves a nonspontaneous redox reaction?

- A. fuel cell
- B. electroplating
- C. redox titration
- D. carbon dry cell

46. Consider the following redox reaction:



In a redox titration, 0.060 mol of  $\text{KMnO}_4$  reacts completely with a solution of  $\text{Sn}(\text{NO}_3)_2$ . How many moles of  $\text{Sn}(\text{NO}_3)_2$  were present in the solution?

- A. 0.024 mol
- B. 0.060 mol
- C. 0.15 mol
- D. 0.30 mol

47. What substances are formed at the anode and cathode during electrolysis of molten sodium chloride,  $\text{NaCl}_{(l)}$ ?

	ANODE	CATHODE
A.	$\text{O}_2$	$\text{H}_2$
B.	Na	$\text{Cl}_2$
C.	$\text{Cl}_2$	$\text{H}_2$
D.	$\text{Cl}_2$	Na

48. What is the minimum voltage required to form nickel from an aqueous solution of  $\text{NiI}_2$  using inert electrodes?
- A. 0.26 V  
B. 0.28 V  
C. 0.54 V  
D. 0.80 V

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

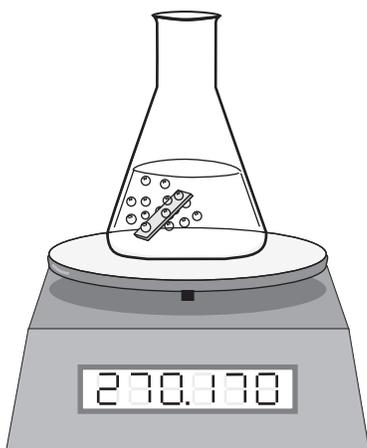
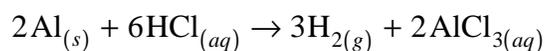
## PART B: WRITTEN RESPONSE

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. An experiment is done to determine the rate of the following reaction:



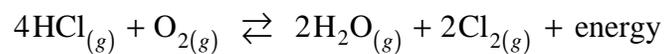
The following data are collected:

TIME (s)	MASS OF FLASK PLUS CONTENTS (g)
0.0	270.230
30.0	270.200
60.0	270.170

Calculate the rate of consumption of Al in mol/min.

(3 marks)

2. Consider the following equilibrium:



a) How does the **entropy** change in the forward direction? Explain your reasoning. **(1 mark)**

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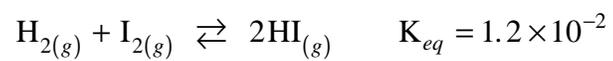
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b) How does the **enthalpy** change in the forward direction? Explain your reasoning. **(1 mark)**

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3. Consider the following equilibrium:



A 2.0L flask is filled with 0.10 mol HI. Calculate the concentration of  $\text{H}_2$  at equilibrium.

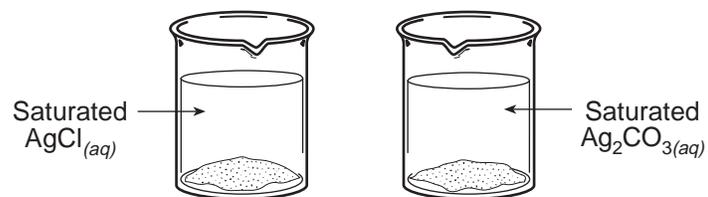
**(3 marks)**

4. The solubility of  $\text{Mn}(\text{IO}_3)_2$  is  $4.8 \times 10^{-3}$  mol/L.

a) Write the net ionic equation that describes a saturated solution of  $\text{Mn}(\text{IO}_3)_2$ . **(1 mark)**

b) Calculate the concentrations of the ions in a saturated solution of  $\text{Mn}(\text{IO}_3)_2$ . **(1 mark)**

5. Consider the following saturated solutions at 25°C:



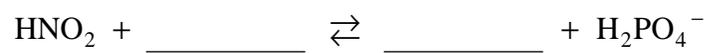
Using calculations, identify the solution with the greater  $[\text{Ag}^+]$ .

**(5 marks)**

6. Consider a Brønsted-Lowry acid-base equation, where  $\text{HNO}_2$  is a reactant and  $\text{H}_2\text{PO}_4^-$  is a product.

a) Complete the following equation.

**(1 mark)**



b) Identify the weaker base in the equilibrium in part a).

**(1 mark)**

7. A chemist prepares a solution by dissolving the salt  $\text{NaIO}_3$  in water.

a) Write the equation for the dissociation reaction that occurs.

**(1 mark)**

b) Write the equation for the hydrolysis reaction that occurs.

**(1 mark)**

c) Calculate the value of the equilibrium constant for the hydrolysis in part b).

**(1 mark)**

8. Calculate the pH of a solution prepared by adding 15.0 mL of 0.500 M  $\text{H}_2\text{SO}_4$  to 35.0 mL of 0.750 M NaOH. **(4 marks)**

9. Balance the following redox reaction in basic solution.

**(3 marks)**



10. Describe **two** chemically different methods that can be used to prevent corrosion of iron and explain why each method works. **(2 marks)**

Method 1: \_\_\_\_\_

\_\_\_\_\_

Explanation: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Method 2: \_\_\_\_\_

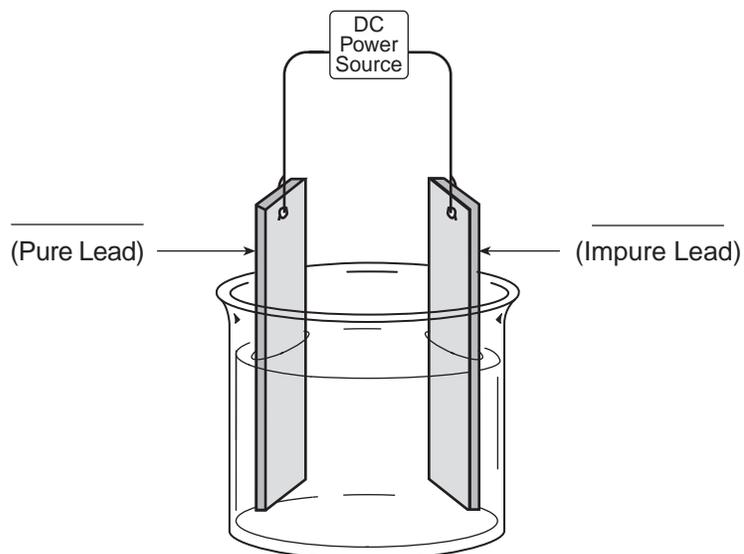
\_\_\_\_\_

Explanation: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

11. Consider the following diagram for the electrorefining of lead:



a) On the diagram above, label the anode and the cathode. **(1 mark)**

b) Write the formula for a suitable electrolyte. **(1 mark)**

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

**END OF EXAMINATION**