INSERT STUDENT I.D. NUMBER (PEN)

STICKER IN THIS SPACE

APRIL 1995

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 INK 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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FOR OFFICE USE ONLY

INSERT STUDENT I.D. NUMBER (PEN)

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CHEMISTRY 12 APRIL 1995 PROVINCIAL
(CHP)

1. _____ (4)

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10. _____ (3)

11. _____ (4)

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CHEMISTRY 12 PROVINCIAL EXAMINATION

		Value	Suggested Time
1. This examination consists of **two** parts:			
PART A	48 multiple-choice questions	48	70
PART B	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. The minimum amount of energy needed to start a reaction is called the

   A. activation energy.
   B. energy of reaction.
   C. entropy of reaction.
   D. reaction mechanism energy.

2. An 8.00 g piece of magnesium was placed into 6.0 M HCl. After 25 s, 3.50 g of unreacted magnesium remained. The average rate at which magnesium was consumed is

   A. 0.14 g/s
   B. 0.18 g/s
   C. 0.32 g/s
   D. 4.50 g/s

3. In general, reaction rates double when the temperature is increased by 10°C. The temperature of a reaction is increased by 40°C. The rate of the reaction will increase by a factor of

   A. 2
   B. 4
   C. 8
   D. 16

4. Consider the following factors:

   I. reactant particles collide
   II. sufficient kinetic energy is present
   III. a favourable geometry exists
   IV. catalysts are present

   Which combination of the above factors is required for all successful collisions?

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

OVER

5. Consider the following reaction:

$$2MnO_{4(aq)}^{-} + 5C_2O_4^{2-}{}_{(aq)} + 16H_{(aq)}^{+} \rightarrow 2Mn^{2+}{}_{(aq)} + 10CO_{2(g)} + 8H_2O_{(l)}$$

The rate of decomposition of the oxalate ion is increased by

A. adding NaOH.
B. removing CO_2.
C. adding a catalyst.
D. decreasing the pressure.

6. A saturated $NaCl_{(aq)}$ solution is an example of an equilibrium system because of the reversible nature of

A. solidifying and melting.
B. crystallizing and dissolving.
C. evaporating and condensing.
D. crystal structure and bond energy.

7. In which of the following systems will the factors of entropy and enthalpy **both** favour the reactants?

A. $3C_{(s)} + 3H_{2(g)} + \text{heat} \rightleftarrows C_3H_{6(g)}$
B. $PCl_{5(g)} + \text{heat} \rightleftarrows PCl_{3(g)} + Cl_{2(g)}$
C. $NH_4Cl_{(s)} + \text{heat} \rightleftarrows NH_{4(aq)}^{+} + Cl_{(aq)}^{-}$
D. $Cl_{2(g)} + 2HI_{(g)} \rightleftarrows I_{2(g)} + 2HCl_{(g)} + \text{heat}$

8. Consider the following equilibrium system:

$$2SO_{2(g)} + O_{2(g)} \rightleftarrows 2SO_{3(g)} \qquad \Delta H = -197 \text{ kJ}$$

Which of the following will **not** shift the equilibrium to the right?

A. adding more O_2
B. adding a catalyst
C. increasing the pressure
D. lowering the temperature

9. Consider the following equilibrium system:

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

Which of the following, when added to the system above, would result in a net decrease in $[H_2O]$?

A. CO_2

B. H_2

C. CO

D. H_2O

10. For an exothermic reaction at equilibrium, an increase in temperature will cause the equilibrium to shift

A. left and K_{eq} increases.

B. left and K_{eq} decreases.

C. right and K_{eq} increases.

D. right and K_{eq} decreases.

11. Consider the following equilibrium system:

$$3O_{2(g)} \rightleftarrows 2O_{3(g)} \qquad K_{eq} = 1$$

Which equation compares the concentration of oxygen and ozone?

A. $[O_2] = [O_3]^{\frac{2}{3}}$

B. $[O_2] = [O_3]$

C. $[O_2] = [O_3]^{\frac{3}{2}}$

D. $[O_2]^{\frac{2}{3}} = [O_3]$

12. Identify the equilibrium system that **least** favours the formation of products.

A. $2HgO_{(s)} \rightleftarrows 2Hg_{(l)} + O_{2(g)}$ $\qquad K_{eq} = 1.2 \times 10^{-22}$

B. $CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + CH_3COO^-_{(aq)}$ $\qquad K_{eq} = 1.8 \times 10^{-5}$

C. $2NO_{(g)} + O_{2(g)} \rightleftarrows 2NO_{2(g)}$ $\qquad K_{eq} = 6.5 \times 10^{5}$

D. $H_{2(g)} + Cl_{2(g)} \rightleftarrows 2HCl_{(g)}$ $\qquad K_{eq} = 1.8 \times 10^{33}$

OVER

13. Consider the following equilibrium system:

$$PCl_{5(g)} \rightleftarrows PCl_{3(g)} + Cl_{2(g)}$$

At equilibrium, $[PCl_5]$ is 0.400 M, $[PCl_3]$ is 1.50 M and $[Cl_2]$ is 0.600 M. The K_{eq} for the reaction is

A. 0.360
B. 0.444
C. 0.900
D. 2.25

14. In a 200 mL sample of 0.030 M Na_3PO_4, the $[Na^+]$ is

A. 0.006 M
B. 0.010 M
C. 0.018 M
D. 0.090 M

15. Saturated solutions of Na_2S, CuS, SnS_2 and Al_2S_3 are prepared at $25°C$. The $[S^{2-}]$ will be **greatest** in the solution of

A. Na_2S
B. CuS
C. SnS_2
D. Al_2S_3

16. The precipitate formed when equal volumes of 0.2 M $Sr(OH)_2$ and 0.2 M MgS are mixed is

A. SrS
B. $Mg(OH)_2$
C. a mixture of $Mg(OH)_2$ and SrS
D. a mixture of $Sr(OH)_2$ and MgS

17. A solution contains CO_3^{2-} and OH^-. Separation of these two anions by selective precipitation is accomplished by first adding $Sr(NO_3)_2$ solution, then filtering and finally adding to the filtrate a solution of

A. HNO_3

B. $RbNO_3$

C. NH_4NO_3

D. $Zn(NO_3)_2$

18. The K_{sp} expression for calcium hydroxide is

A. $K_{sp} = [Ca^{2+}][OH^-]^2$

B. $K_{sp} = \dfrac{1}{[Ca^{2+}][OH^-]^2}$

C. $K_{sp} = [Ca^{2+}][2OH^-]^2$

D. $K_{sp} = \dfrac{1}{[Ca^{2+}][2OH^-]^2}$

19. In a saturated solution of manganese(II) hydroxide, $Mn(OH)_2$, $[Mn^{2+}]$ equals $4.5\times10^{-5}\,M$. Therefore, the K_{sp} of $Mn(OH)_2$ is

A. 9.1×10^{-14}

B. 3.6×10^{-13}

C. 2.0×10^{-9}

D. 4.1×10^{-9}

20. Sodium iodide is added to a saturated solution of lead(II) iodide. The net change is

A. $[I^-]$ increases and $[Pb^{2+}]$ increases.

B. $[I^-]$ decreases and $[Pb^{2+}]$ decreases.

C. $[I^-]$ increases and $[Pb^{2+}]$ decreases.

D. $[I^-]$ decreases and $[Pb^{2+}]$ increases.

OVER

21. The acid used in the lead-acid storage battery is

A. HCl
B. HNO_3
C. H_2SO_4
D. CH_3COOH

22. In the equilibrium system:

$$H_2BO_{3(aq)}^- + HCO_{3(aq)}^- \rightleftarrows H_2CO_{3(aq)} + HBO_3{}^{2-}_{(aq)}$$

The two species acting as Brönsted-Lowry acids are

A. $HCO_3{}^-$ and H_2CO_3
B. $H_2BO_3{}^-$ and H_2CO_3
C. $HCO_3{}^-$ and $HBO_3{}^{2-}$
D. $H_2BO_3{}^-$ and $HBO_3{}^{2-}$

23. In the following Brönsted-Lowry acid-base equation:

$$NH_{4(aq)}^+ + H_2O_{(l)} \rightleftarrows NH_{3(aq)} + H_3O_{(aq)}^+$$

The stronger base is

A. $NH_4{}^+$
B. H_2O
C. NH_3
D. H_3O^+

24. Consider the following equilibrium system:

$$OCl_{(aq)}^- + HC_7H_5O_{2(aq)} \rightleftarrows HOCl_{(aq)} + C_7H_5O_{2(aq)}^- \qquad K_{eq} = 2.1\times10^3$$

At equilibrium,

A. products are favoured and HOCl is the stronger acid.
B. reactants are favoured and HOCl is the stronger acid.
C. products are favoured and $HC_7H_5O_2$ is the stronger acid.
D. reactants are favoured and $HC_7H_5O_2$ is the stronger acid.

25. Consider the following acid-base indicator:

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

When this indicator is added to different solutions, the following data are obtained:

Solution	1.0 M HCl	1.0 M HA_1	1.0 M HA_2
Colour	yellow	blue	yellow

The acids HA_1, HA_2 and HInd listed in the order of **decreasing** acid strength is

A. HA_2, HInd, HA_1
B. HInd, HA_1, HA_2
C. HA_2, HA_1, HInd
D. HA_1, HInd, HA_2

26. When added to water, the hydrogen carbonate ion, HCO_3^-, produces a solution which is

A. basic because K_b is greater than K_a
B. basic because K_a is greater than K_b
C. acidic because K_a is greater than K_b
D. acidic because K_b is greater than K_a

27. Consider the following salts:

I. NaF II. $NaClO_4$ III. $NaHSO_4$

Which of these salts, when dissolved in water, would form a basic solution?

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

28. The pH scale is

A. direct.
B. inverse.
C. logarithmic.
D. exponential.

OVER

29. A solution is prepared by adding 100 mL of 10 M of HCl to a 1 litre volumetric flask and filling it to the mark with water. The pH of this solution is

A. –1
B. 0
C. 1
D. 7

30. The approximate pH of a 0.06 M solution of CH_3COOH is

A. 1
B. 3
C. 11
D. 13

31. Which of the following indicators would be used when titrating a weak acid with a strong base?

A. methyl red
B. methyl violet
C. indigo carmine
D. phenolphthalein

32. Consider the following equilibrium for an acid-base indicator:

$$HInd \rightleftarrows H^+ + Ind^- \qquad K_a = 1.0 \times 10^{-10}$$

Which of the following statements is correct at pH 7.0 ?

A. $\left[Ind^-\right] < \left[\ HInd\ \right]$
B. $\left[Ind^-\right] = \left[\ HInd\ \right]$
C. $\left[Ind^-\right] > \left[\ HInd\ \right]$
D. $\left[Ind^-\right] = \left[H^+\right] = [HInd]$

33. Consider the following acid solutions:

I. H_2CO_3 II. $HClO_4$ III. HF

Which of the above acids would form a buffer solution when its conjugate base is added?

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

34. The approximate pH of "normal" rain water is

A. 0
B. 6
C. 7
D. 8

35. Consider the following 0.100 M solutions:

I. H_2SO_4 II. HCl III. HF

The equivalence point is reached when 10.00 mL of 0.100 M NaOH has been added to 10.00 mL of solution(s)

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

36. Which of the following oxides would hydrolyze to produce hydronium ions?

A. CaO
B. SO_2
C. MgO
D. Na_2O

37. An oxidizing agent is

A. reduced as it loses electrons.
B. reduced as it gains electrons.
C. oxidized as it loses electrons.
D. oxidized as it gains electrons.

OVER

38. Which of the following is the **strongest** oxidizing agent?

A. Mn

B. Mn^{2+}

C. acidified MnO_2

D. acidified MnO_4^-

39. The reducing agents yttrium, uranium and vanadium, from the strongest to the weakest, are Y, U and V. Which of the following statements is true?

A. V will react with the Y^{3+} ion.

B. V will react with the U^{3+} ion.

C. V will react with both the U^{3+} and Y^{3+} ions.

D. V will not react with either U^{3+} or Y^{3+} ions.

40. Which of the following reactions is spontaneous?

A. $Fe + Cu^{2+} \rightarrow Fe^{2+} + Cu$

B. $Fe + Zn^{2+} \rightarrow Fe^{2+} + Zn$

C. $Fe + Mn^{2+} \rightarrow Fe^{2+} + Mn$

D. $Fe + Mg^{2+} \rightarrow Fe^{2+} + Mg$

41. The oxidation number of sulphur in $Na_2S_2O_3$ is

A. -2

B. $+1$

C. $+2$

D. $+4$

42. Consider the following:

$$Cl_2 \rightarrow ClO_3^-$$

The balanced half-reaction is

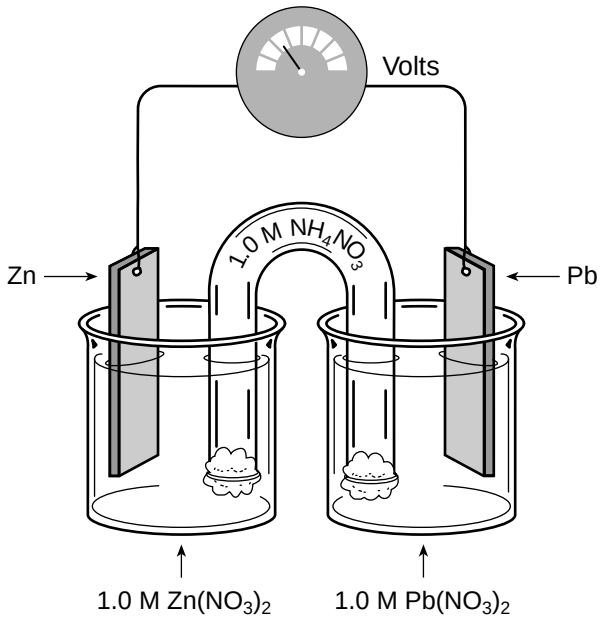
A. $Cl_2 + 3H_2O \rightarrow ClO_3^- + 6H^+ + 5e^-$

B. $Cl_2 + 3H_2O \rightarrow 2ClO_3^- + 6H^+ + 4e^-$

C. $Cl_2 + 6H_2O + 2e^- \rightarrow 2ClO_3^- + 6H_2$

D. $Cl_2 + 6H_2O \rightarrow 2ClO_3^- + 12H^+ + 10e^-$

Use the following cell diagram to answer questions 43, 44 and 45.



43. The reaction at the anode is

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

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

C. $Zn^{2+} + 2e^- \rightarrow Zn$

D. $Zn \rightarrow Zn^{2+} + 2e^-$

44. The electrons move from the

A. zinc to the lead through the wire.
B. lead to the zinc through the wire.
C. zinc to the lead through the salt bridge.
D. lead to the zinc through the salt bridge.

45. When the cell establishes equilibrium, the voltage will be

A. -0.63 V

B. 0.00 V

C. $+0.63$ V

D. $+0.89$ V

OVER

46. Which of the following should be used to cathodically protect an iron sculpture?

A. lead
B. nickel
C. copper
D. magnesium

47. The substance formed at the cathode during the electrolysis of molten $ZnCl_2$ is

A. zinc.
B. oxygen.
C. chlorine.
D. hydrogen.

48. In electrorefining lead, pure lead is deposited on the cathode from an impure lead anode. In this process, lead is

A. reduced at the anode.
B. oxidized at the anode.
C. reduced at the anode and the cathode.
D. oxidized at the anode and the cathode.

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. Nitric oxide (NO) is involved in the decomposition of ozone (O_3) by the following mechanism:

Step 1	$O_3 + \text{sunlight} \rightarrow O_2 + O$
Step 2	$O_3 + NO \rightarrow NO_2 + O_2$
Step 3	$NO_2 + O \rightarrow NO + O_2$

a) Write the net equation for the decomposition reaction. **(1 mark)**

_____

b) Identify a catalyst. **(1 mark)**

_____

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

_____

d) What is the function of sunlight in this reaction? (**1 mark)**

_____

_____

Score for Question 1:

1. _____ (4)

OVER

2. a) Why are chemical equilibria referred to as dynamic? **(1 mark)**

_____

_____

b) How is a chemical system at equilibrium recognized? (**1 mark)**

_____

_____

Score for Question 2:

2. _____ (2)

3. Consider the following equilibrium system:

$$C_{(s)} + 2H_{2(g)} \rightleftarrows CH_{4(g)} \qquad K_{eq} = 8.1 \times 10^{8} \text{ at } 25^{\circ}C$$

A student places 4.5 mol of carbon, 3.6×10^{-3} mol of hydrogen and 5.1 mol of methane in a 1.0 L flask. The student predicts that the $[CH_4]$ increases as equilibrium is established. Do you agree? Explain your answer using appropriate calculations. **(3 marks)**

Score for Question 3:

3. _____ (3)

4. Consider the following solubility equilibrium:

$$AgIO_{3(s)} + \text{heat} \rightleftarrows Ag^{+}_{(aq)} + IO^{-}_{3(aq)}$$

State **two** methods by which more $AgIO_3$ solid may be precipitated out of solution. **(2 marks)**

_____

_____

_____

Score for Question 4:

4. _____ (2)

5. Calculate the maximum moles of Br^- that can exist in 0.500 L of $0.10\ M\ Pb(NO_3)_2$. **(4 marks)**

Score for Question 5:

5. _____ (4)

OVER

6. In an acid-base reaction, the **two Brönsted-Lowry acids** are hydrofluoric acid (HF) and the hydrogen sulphite ion $\left(HSO_3^-\right)$. Write the equation for this reaction.
(2 marks)

Score for Question 6:

6. _____
(2)

7. a) Write an equilibrium equation to represent the hydrolysis of ammonia in water.
(1 mark)

b) Calculate the value of the equilibrium constant. **(1 mark)**

Score for Question 7:

7. _____
(2)

8. Tomato juice has a pH of 4.20. Calculate the $\left[H_3O^+\right]$ and $\left[OH^-\right]$ in tomato juice. **(2 marks)**

Score for Question 8:
8. _____ (2)

9. Calculate the pH of a solution prepared by adding 60.0 mL of 0.150 M HCl to 140.0 mL of 0.100 M KOH. **(4 marks)**

Score for Question 9:
9. _____ (4)

OVER

10. Balance the following redox reaction. **(3 marks)**

$$Cu + NO_3^- \rightarrow Cu^{2+} + NO \qquad \text{(in acid)}$$

Score for Question 10:
10. _____ (3)

11. In a titration, a 1.00 mL sample of an antiseptic solution containing hydrogen peroxide required 17.6 mL of a 0.0200 M solution of $KMnO_4$ to reach the endpoint. The equation for the reaction is

$$5H_2O_2 + 2MnO_4^- + 6H^+ \rightarrow 5O_2 + 2Mn^{2+} + 8H_2O$$

a) Identify the reducing agent. **(1 mark)**

b) Calculate the concentration of H_2O_2 in the antiseptic solution. **(3 marks)**

Score for Question 11:
11. _____ (4)

END OF EXAMINATION