INSERT STUDENT I.D. NUMBER (PEN)

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JUNE 1994

PROVINCIAL EXAMINATION

• MINISTRY OF EDUCATION •

CHEMISTRY 12

GENERAL INSTRUCTIONS

1. Insert the stickers with your Student I.D. Number (PEN) in the allotted spaces above. **Under no circumstance is your name or identification, other than your Student I.D. Number, to appear on this paper.**

2. Take the separate Answer Sheet and follow the directions on its front page.

3. Be sure you have an HB pencil and an eraser for completing your Answer Sheet. Follow the directions on the Answer Sheet when answering multiple-choice questions.

4. For each of the written-response questions, write your answer in the space provided. 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**.

5. 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.

6. Be sure you have the separate **Data Booklet**.

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FOR OFFICE USE ONLY

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CHEMISTRY 12 JUNE 1994 PROVINCIAL (CHP)

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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:	12 written-response questions	32	50
	Total:	80 marks	120 minutes

2. You have **TWO HOURS** to complete this examination.

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
   - K_{sp} Values
   - Relative Strengths of Brönsted-Lowry Acids and Bases
   - Acid-base Indicators
   - Two-place Logarithms
   - Standard Reduction Potentials of Half-cells.

   No other reference materials or tables are allowed.

4. An approved scientific calculator is considered essential for the examination. The calculator **MUST NOT** be programmable to process alpha-numeric strings, nor should it be capable of processing user-defined functions. It **MUST NOT** have the capacity to accept coefficients from either an equation or a system of equations, thereby producing the roots of that equation or system. The calculator **MUST NOT** contain a plotter or printer.

5. **FOR WRITTEN RESPONSE QUESTIONS:**

   i) Organization and planning space has been incorporated into the space allowed for each question.

   ii) Answers must include units where appropriate and be given to the correct number of significant figures.

   iii) In questions involving calculation, full marks will not be given for providing only an answer.

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PART A: MULTIPLE–CHOICE QUESTIONS

Value: 48 marks (one mark per question) **Suggested Time: 70 minutes**

INSTRUCTIONS:	For each question, select the **BEST** answer and record your choice on the answer sheet provided. Using an **HB** pencil, completely fill in the circle that has the letter corresponding to your answer.

1. Consider the following reaction:

$$NaOH_{(aq)} + HCl_{(aq)} \longrightarrow H_2O_{(l)} + NaCl_{(aq)}$$

The rate of this reaction could be determined by monitoring the change in concentration of

A. H^+
B. Cl^-
C. Na^+
D. H_2O

2. Consider the following reaction:

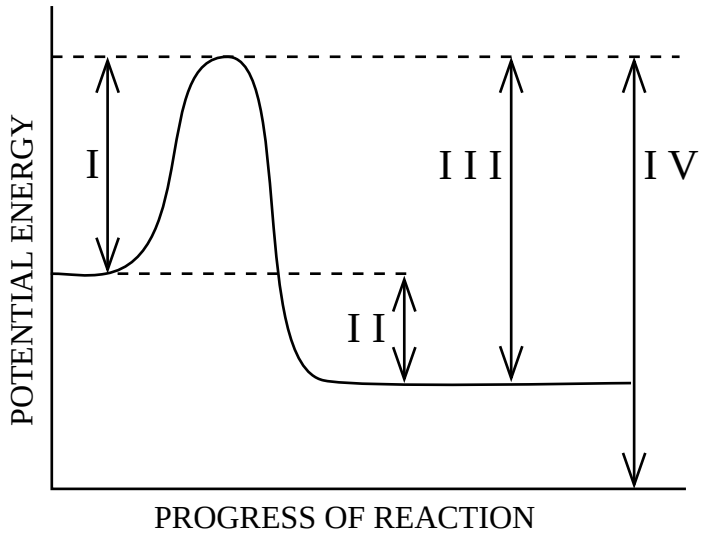
$$Mg_{(s)} + 2HCl_{(aq)} \longrightarrow MgCl_{2(aq)} + H_{2(g)}$$

As the temperature of the above system is increased, the number of collisions

A. increases but fewer are effective.
B. decreases and fewer are effective.
C. increases and more are effective.
D. decreases but more are effective.

OVER

3. Consider the following potential energy diagram:



The energy interval that represents the activation energy for the **reverse** reaction is

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

4. Consider the following two-step reaction mechanism:

step one $NO_{2(g)} + NO_{2(g)} \longrightarrow NO_{(g)} + NO_{3(g)}$ slow

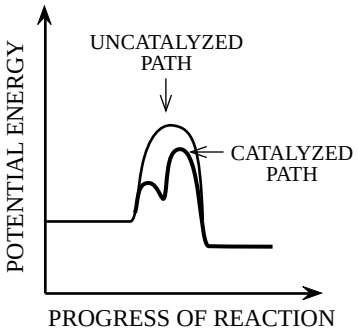
step two $NO_{3(g)} + CO_{(g)} \longrightarrow CO_{2(g)} + NO_{2(g)}$ fast

Which one of the following changes would result in the greatest increase in reaction rate?

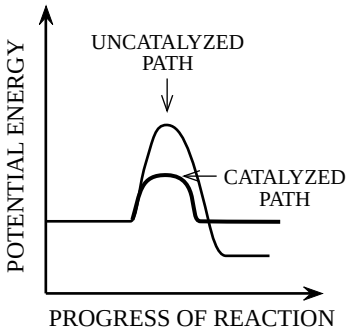
A. increase [CO]
B. decrease [NO]
C. increase [NO_2]
D. decrease [NO_3]

5. An uncatalyzed reaction was found to produce 40 kJ of energy in 10 minutes. When catalyzed, the same reaction produced 40 kJ of energy in 2 minutes. Which one of the following potential energy diagrams is consistent with the above data?

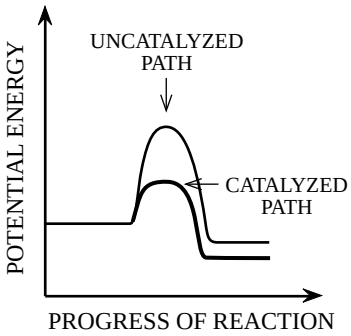
A.



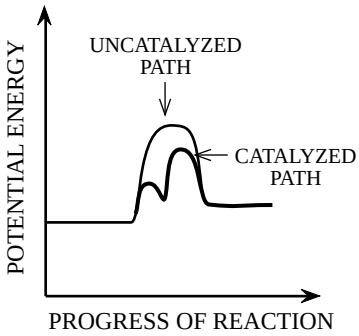
B.



C.



D.



6. Macroscopic properties become constant in an equilibrium system when

   A. all reactions have stopped.
   B. the reactants are completely used up.
   C. maximum enthalpy has been reached.
   D. forward and reverse reaction rates are equal.

7. In which of the following systems would the tendencies toward minimum enthalpy and maximum entropy be in opposition to each other?

   A. $Br_{2(l)} + \text{heat} \rightarrow Br_{2(g)}$

   B. $NaOH_{(s)} \rightarrow Na^{+}_{(aq)} + OH^{-}_{(aq)} + \text{heat}$

   C. $2C_{(g)} + 2H_{2(g)} \rightarrow C_2H_{4(g)}$ ΔH is positive

   D. $K_{(s)} + H_2O_{(l)} \rightarrow K^{+}_{(aq)} + OH^{-}_{(aq)} + \frac{1}{2}H_{2(g)}$ ΔH is negative

OVER

8. Consider the following equilibrium system:

$$FeO_{(s)} + H_{2(g)} \rightleftarrows Fe_{(s)} + H_2O_{(g)}$$

Which one of the following statements describes the effect that a decrease in volume would have on the position of equilibrium and the $[H_2]$ in the above system?

A. No shift, $[H_2]$ increases.
B. Shift right, $[H_2]$ increases.
C. Shift right, $[H_2]$ decreases.
D. No shift, $[H_2]$ remains constant.

9. Tooth enamel, $Ca_5(PO_4)_3OH$ establishes the following equilibrium:

$$Ca_5(PO_4)_3OH_{(s)} \rightleftarrows 5Ca^{2+}_{(aq)} + 3PO^{3-}_{4(aq)} + OH^-_{(aq)}$$

Which one of the following, when added to the above equilibrium system, would result in a shift to the right?

A. $H^+_{(aq)}$
B. $OH^-_{(aq)}$
C. $Ca^{2+}_{(aq)}$
D. $Ca_5\left(PO_4\right)_3OH_{(s)}$

10. Consider the following equilibrium system:

$$SnO_{2(s)} + 2CO_{(g)} \rightleftarrows Sn_{(s)} + 2CO_{2(g)}$$

The equilibrium constant expression for the above system is

A. $K_{eq} = \dfrac{[CO_2]^2}{[CO]^2}$

B. $K_{eq} = \dfrac{[2CO_2]^2}{[2CO]^2}$

C. $K_{eq} = \dfrac{[CO_2]^2\ [Sn]}{[CO]^2[SnO_2]}$

D. $K_{eq} = \dfrac{[2CO_2]^2\ [Sn]}{[2CO]^2[SnO_2]}$

11. An equal number of moles of $I_{2(g)}$ and $Br_{2(g)}$ are placed into a closed container and allowed to establish the following equilibrium:

$$I_{2(g)} + Br_{2(g)} \rightleftarrows 2IBr_{(g)} \qquad K_{eq} = 280$$

Which one of the following relates $[IBr]$ to $[I_2]$ at equilibrium?

A. $[I_2] = [IBr]$
B. $[I_2] < [IBr]$
C. $[I_2] = 2[IBr]$
D. $[I_2] = 280[IBr]$

12. Consider the following equilibrium system:

$$2NO_{(g)} + O_{2(g)} \rightleftarrows 2NO_{2(g)} \qquad K_{eq} = 65$$

At equilibrium, the [NO] = 0.600 M and the $[O_2]$ = 0.300 M. Using this data, the equilibrium $[NO_2]$ is

A. 7.0 M
B. 3.4 M
C. 2.6 M
D. 0.60 M

13. Consider the following equilibrium system:

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

1.00 mole of CO_2 and 2.00 moles of $H_{2(g)}$ are placed into a 2.00 litre container. At equilibrium, the [CO] = 0.31 mol/L. Based on this data, the equilibrium $[CO_2]$ is

A. 0.19 M
B. 0.31 M
C. 0.38 M
D. 0.69 M

OVER

14. Molecular solutions do not conduct electricity because they contain

A. molecules only.
B. cations and anions.
C. molecules and anions.
D. molecules and cations.

15. To determine the solubility of a solute in water, a solution must be prepared that is

A. saturated.
B. unsaturated.
C. concentrated.
D. supersaturated.

16. From the list of salts below, how many are considered soluble at 25°C?

$CuCl_2$ $CaSO_4$ PbS Ag_3PO_4

A. zero
B. one
C. two
D. three

17. Identify the **most** soluble sulphide.

A. HgS, $K_{sp} = 1.6 \times 10^{-54}$

B. PbS, $K_{sp} = 7.0 \times 10^{-29}$

C. FeS, $K_{sp} = 3.7 \times 10^{-19}$

D. MnS, $K_{sp} = 2.3 \times 10^{-13}$

18. During a lab on qualitative analysis, an unknown solution containing one cation was analyzed and the following data were collected:

0.2 M Anions Added to the Unknown Solution	**Observation**
S^{2-}	no precipitate
SO_4^{2-}	precipitate
OH^-	precipitate
CO_3^{2-}	precipitate

Which one of the following cations is found in the unknown solution?

A. Mg^{2+}

B. Ca^{2+}

C. Sr^{2+}

D. Ba^{2+}

19. Which one of the following equilibrium systems is described by a K_{sp} ?

A. $CaCO_{3(s)} \rightleftarrows CaO_{(s)} + CO_{2(g)}$

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

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

D. $Ca(OH)_{2(aq)} + H_2CO_{3(aq)} \rightleftarrows CaCO_{3(s)} + 2H_2O_{(l)}$

20. In an experiment, a student mixes equal volumes of 0.0020 M Pb^{2+} ions with 0.0040 M I^- ions. The trial ion product is

A. 4.0×10^{-9}

B. 3.2×10^{-8}

C. 1.3×10^{-7}

D. 8.0×10^{-6}

OVER

21. To distinguish between a strong acid and a strong base, an experimenter could use

A. odour.
B. magnesium.
C. a conductivity test.
D. the common ion test.

22. The hydronium ion, H_3O^+ is a water molecule that has

A. lost a proton.
B. gained a proton.
C. gained a neutron.
D. gained an electron.

23. How many acids from the list below are known to be weak acids?

$HCl, \quad HF, \quad H_2SO_3, \quad H_2SO_4, \quad HNO_3, \quad HNO_2:$

A. 2
B. 3
C. 4
D. 5

24. If reactants are favoured in the following equilibrium, the stronger base must be

$$HCN + HS^- \rightleftarrows H_2S + CN^-$$

A. H_2S
B. HS^-
C. CN^-
D. HCN

25. A new indicator, "B.C. Blue (HInd)," is red in bases and blue in acids. Describe the shift in equilibrium and the resulting colour change if 1.0 M HIO_3 is added to a neutral, purple solution of this indicator.

$$HInd + H_2O \rightleftarrows H_3O^+ + Ind^-$$

A. Equilibrium shifts left, colour becomes red.
B. Equilibrium shifts left, colour becomes blue.
C. Equilibrium shifts right, colour becomes red.
D. Equilibrium shifts right, colour becomes blue.

26. An aqueous solution at room temperature is analyzed and the $[H_3O^+]$ is found to be 2.0×10^{-3} M. The $[OH^-]$ is

A. 5.0×10^{-12} M
B. 2.0×10^{-11} M
C. 4.0×10^{-6} M
D. 2.0×10^{-3} M

27. In water, the hydrogen sulphide ion, HS^-, will act as

A. an acid because the $K_a < K_b$
B. an acid because the $K_a > K_b$
C. a base because the $K_a < K_b$
D. a base because the $K_a > K_b$

28. The K_b for the dihydrogen phosphate ion is

A. 1.4×10^{-12}
B. 6.3×10^{-8}
C. 1.6×10^{-7}
D. 7.1×10^{-3}

29. The net ionic equation for the hydrolysis of the salt, Na_2S, is

A. $Na_2S \rightleftarrows 2Na^+ + S^{2-}$
B. $S^{2-} + H_2O \rightleftarrows OH^- + HS^-$
C. $Na_2S + 2H_2O \rightleftarrows 2NaOH + H_2S$
D. $2Na^+ + S^{2-} + 2H_2O \rightleftarrows 2Na^+ + 2OH^- + H_2S$

30. The pOH of a 0.025 M $HClO_4$ solution is

A. 0.94
B. 1.60
C. 12.40
D. 13.06

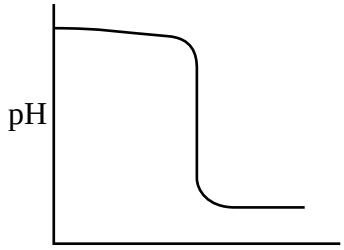
OVER

31. What is the pH at the transition point of an indicator if its K_a is 7.9×10^{-3} ?

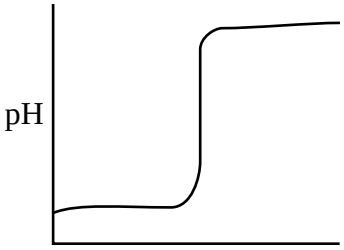
A. 0.98
B. 2.10
C. 7.00
D. 11.90

32. Which of the following curves **best** represents the titration of sodium hydroxide with hydrochloric acid?

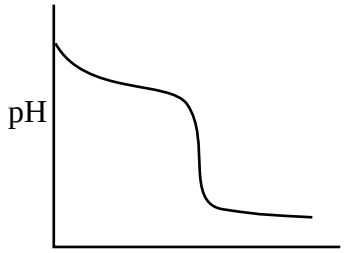
A.



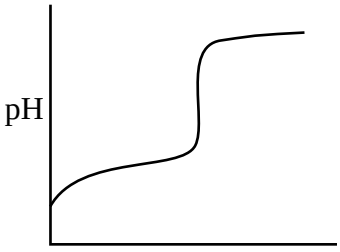
B.



C.



D.



33. The **complete** ionic equation for the neutralization of acetic acid by sodium hydroxide is

A. $H^+ + OH^- \rightleftarrows H_2O$

B. $CH_3COOH + OH^- \rightleftarrows CH_3COO^- + H_2O$

C. $CH_3COOH + NaOH \rightleftarrows NaCH_3COO + H_2O$

D. $CH_3COOH + Na^+ + OH^- \rightleftarrows Na^+ + CH_3COO^- + H_2O$

34. Which one of the following combinations would act as an acidic buffer?

A. HCl and NaOH
B. KOH and KBr
C. NH_3 and NH_4Cl
D. CH_3COOH and $NaCH_3COO$

35. A student prepares a buffer by placing ammonium chloride in a solution of ammonia. Equilibrium is established according to the equation:

$$NH_3 + H_2O \rightleftarrows NH_4^+ + OH^-$$

When a small amount of base is added to the buffer, the base reacts with the

A. NH_3 and the pH decreases.

B. NH_4^+ and the pH decreases.

C. NH_3 to keep the pH relatively constant.

D. NH_4^+ to keep the pH relatively constant.

36. The balanced equation for the reaction between sodium oxide and water is

A. $Na_2O + H_2O \rightarrow 2NaOH$

B. $Na_2O + H_2O \rightarrow 2NaH + O_2$

C. $Na_2O + H_2O \rightarrow 2Na + H_2O_2$

D. $Na_2O + H_2O \rightarrow 2Na + H_2 + O_2$

37. Consider the reaction:

$$2MnO_4^- + 5CH_3CHO + 6H^+ \rightarrow 5CH_3COOH + 2Mn^{2+} + 3H_2O$$

The reducing agent is

A. Mn^{2+}

B. MnO_4^-

C. CH_3CHO

D. CH_3COOH

38. The equation, $Al \rightarrow Al^{3+} + 3e^-$ represents

A. oxidation.
B. reduction.
C. electrolysis.
D. displacement.

OVER

39. Consider the reaction:

$$2HIO_3 + 5H_2SO_3 \rightarrow I_2 + 5H_2SO_4 + H_2O$$

The skeletal reduction half-reaction is

A. $IO_3^- \rightarrow I_2$

B. $S^{6+} \rightarrow S^{4+}$

C. $H^+ \rightarrow H_2O$

D. $SO_3^{2-} \rightarrow SO_4^{2-}$

40. Consider the following observations:

$$Co^{3+} + Ce^{3+} \rightarrow Co^{2+} + Ce^{4+}$$

$$Co^{2+} + Au^{3+} \rightarrow \text{NO REACTION}$$

$$6Br^- + 2Au^{3+} \rightarrow 2Au + 3Br_2$$

$$Au^{3+} + Ce^{3+} \rightarrow \text{NO REACTION}$$

The oxidizing agents **in order** (starting with the strongest) are

A. Br_2, Au^{3+}, Ce^{4+}, Co^{3+}

B. Co^{3+}, Ce^{4+}, Au^{3+}, Br_2

C. Ce^{4+}, Co^{3+}, Au^{3+}, Br_2

D. Ce^{4+}, Au^{3+}, Co^{2+}, Br_2

41. Using the table of standard reduction potentials, it can be predicted that I^- will react spontaneously with

A. Co

B. Br_2

C. Cl^-

D. Cu^{2+}

42. The oxidation number of oxygen in Na_2O_2 is

A. 0
B. –1
C. –2
D. –4

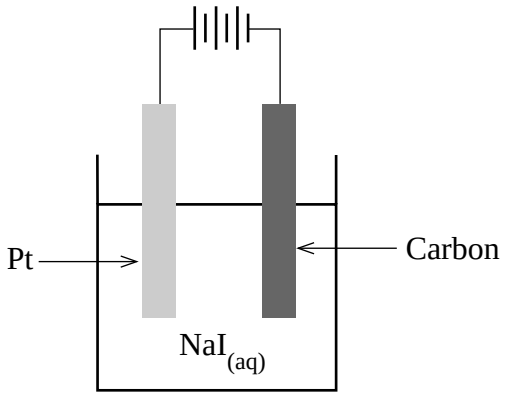
43. Consider the reaction:

$$3C_3H_8O + Cr_2O_7^{2-} + 8H^+ \rightarrow 3C_3H_6O + 2Cr^{3+} + 7H_2O$$

The oxidation number of C is changed by

A. $+\frac{2}{3}$
B. +2
C. $-\frac{2}{3}$
D. –2

44. Consider the cell below:

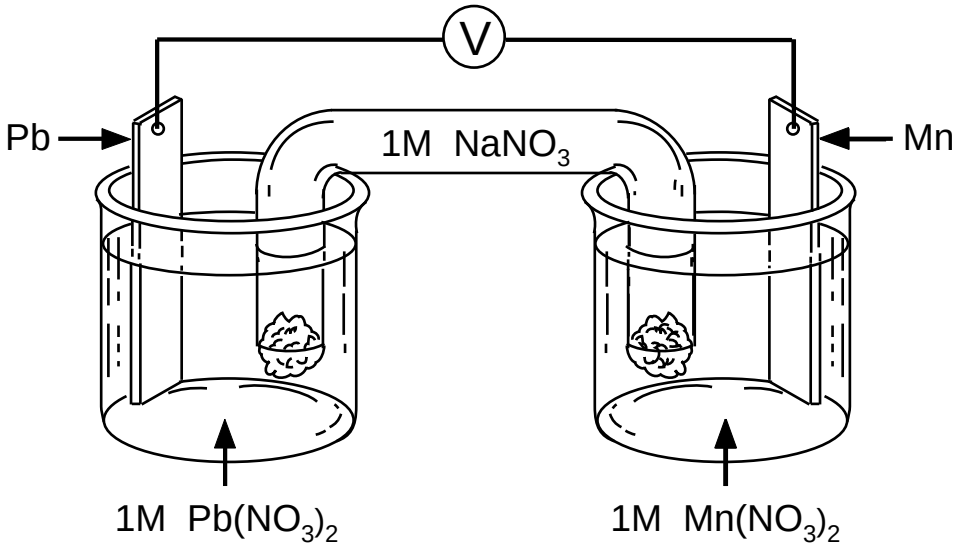


The reaction at the anode is

A. $2I^- \rightarrow I_2 + 2e^-$
B. $Pt \rightarrow Pt^{2+} + 2e^-$
C. $Na \rightarrow Na^+ + 1e^-$
D. $H_2O \rightarrow \frac{1}{2}O_2 + 2H^+ + 2e^-$

OVER

Consider the cell below for questions 45 and 46.



45. The flow of electrons is from

A. Pb to Mn through the wire.
B. Mn to Pb through the wire.
C. Pb to Mn through the salt bridge.
D. Mn to Pb through the salt bridge.

46. As the cell operates,

A. $\left[Pb^{2+}\right]$ and $\left[Mn^{2+}\right]$ increase.

B. $\left[Pb^{2+}\right]$ and $\left[Mn^{2+}\right]$ decrease.

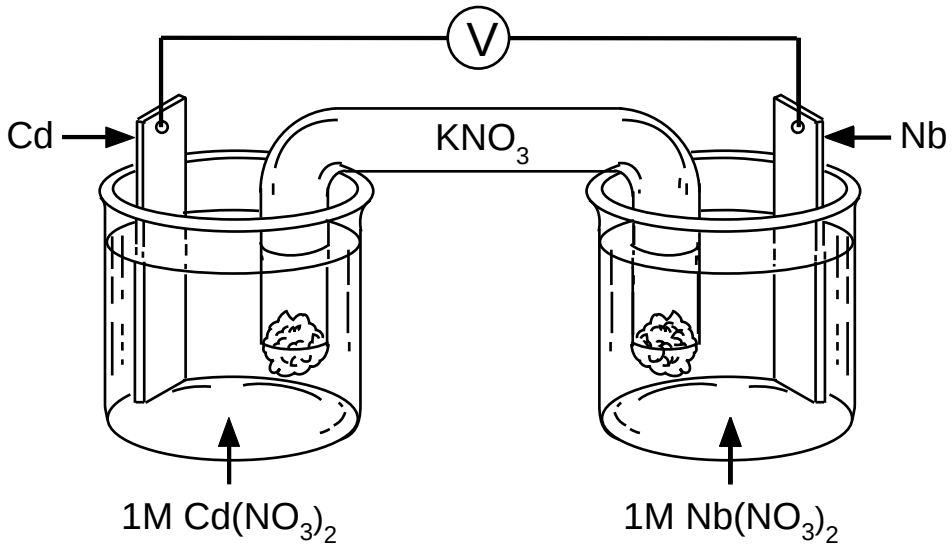
C. $\left[Pb^{2+}\right]$ increases as $\left[Mn^{2+}\right]$ decreases.

D. $\left[Pb^{2+}\right]$ decreases as $\left[Mn^{2+}\right]$ increases.

47. Consider the following half-reactions:

$$Cd^{2+} + 2e^- \leftrightarrow Cd \qquad E° = -0.40 \text{ V}$$
$$Nb^{3+} + 3e^- \leftrightarrow Nb \qquad E° = -1.10 \text{ V}$$

When the cell below is connected, the initial E° value is



A. – 1.50 V
B. – 0.70 V
C. + 0.70 V
D. + 1.50 V

48. As iron corrodes in moist air,

A. the iron loses electrons.
B. water is oxidized.
C. the iron acts as an oxidizing agent.
D. oxygen donates electrons to metal ions.

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

OVER

PART B: WRITTEN–RESPONSE QUESTIONS

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.

In questions involving calculation, full marks will not be given for providing only an answer.

1. Carbon burns in air according to the following equation:

$$C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$$

List **four** ways the rate of the above reaction could be increased. **(2 marks)**

_____

_____

_____

_____

_____

_____

Score for Question 1.

1. _____ (2)

2. Define the term "activation energy". **(2 marks)**

_____

_____

_____

_____

Score for Question 2.

2. _____ (2)

3. Consider the following equilibrium system:

$$C_{(s)} + H_2O_{(g)} \rightleftarrows CO_{(g)} + H_{2(g)} \qquad K_{eq} = 0.80$$

In an experiment, a student places 0.10 mol of C, 0.15 mol of H_2O, 0.25 mol of CO, and 0.20 mol of H_2 into a 1.0 L flask. The student predicts that the [CO] will decrease as equilibrium becomes established. **(3 marks)**

a) Would you agree or disagree with the student? _____

b) Justify your answer, including appropriate calculations.

Score for Question 3.

3. _____ (3)

4. The production of ammonia by the Haber process involves the following equilibrium:

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

The table below indicates the percentage of ammonia in equilibrium mixtures at various temperatures.

Temperature °C	**Percentage of Ammonia in Equilibrium**
200	98
350	80
500	51

a) Explain why the lower temperature results in a higher percentage of ammonia in the equilibrium mixture. **(1 mark)**

_____

_____

b) Explain why a temperature of 500°C is used in the Haber process rather than a lower temperature. **(1 mark)**

_____

_____

Score for Question 4.

4. _____ (2)

OVER

5. A suspension of barium sulphate is used to improve the quality of X-rays in the digestive system. If a patient is required to drink 0.400 L of this suspension, calculate the actual mass in grams of **dissolved** $BaSO_4$. $\left(K_{sp} \text{ of } BaSO_4 = 1.1 \times 10^{-10}\right)$ **(4 marks)**

Score for Question 5.
5. _____ (4)

6. Write an equation that describes the equilibrium present in a saturated solution of $Cu_3(PO_4)_2$. **(2 marks)**

Score for Question 6.
6. _____ (2)

7. a) Write a definition for a conjugate acid-base pair. **(1 mark)**

_____

_____

b) Give one example of a conjugate acid-base pair. **(1 mark)**

_____

_____

Score for Question 7.

7. _____ (2)

8. a) The ionization of water is an endothermic process. What happens to the value of K_w as water is heated? Explain. **(2 marks)**

_____

_____

_____

_____

b) What happens to the pH of pure water as the temperature increases? **(1 mark)**

_____

_____

c) As the temperature of pure water rises, will the water become more acidic, more basic, or remain neutral? **(1 mark)**

_____

_____

Score for Question 8.

8. _____ (4)

OVER

9. What pH results when 0.75 mol of acetic acid is dissolved in enough water to make 3.0 litres of solution? **(4 marks)**

Score for Question 9.
9. _____ (4)

10. Consider the reaction:

$$2Fe^{3+}_{(aq)} + 2I^{-}_{(aq)} \rightarrow 2Fe^{2+}_{(aq)} + I_{2(aq)}$$

Is the reaction spontaneous? Explain. **(2 marks)**

Score for Question 10.
10. _____ (2)

11. Balance the following half-reaction in basic solution. **(2 marks)**

$$CNO^- \rightarrow CN^-$$

Score for Question 11.
11. _____ (2)

12. A series of experiments is performed to measure the E° produced by various combinations of metals in 1.00 M solutions of their salts.

Anode	Cathode	E°(V)
Be	Cd	1.297
Be	Ga	1.180
Ti	Be	0.050

Based on the data above,

a) list the metals in order of their activity (strongest reducing agent first). **(2 marks)**

b) predict the E° of a Ti/Cd cell. **(1 mark)**

Score for Question 12.
12. _____ (3)

END OF EXAMINATION