INSERT STUDENT I.D. NUMBER (PEN)

STICKER IN THIS SPACE

AUGUST 1996

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. **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.

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 AUGUST 1996 PROVINCIAL

Course Code = CH Examination Type = P

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8. _____ (4)

9. _____ (4)

10. _____ (4)

11. _____ (3)

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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. Dust particles suspended in the air inside unheated grain elevators can sometimes react explosively because the dust particles have a

   A. high kinetic energy.
   B. high activation energy.
   C. catalytic effect on the reaction.
   D. large surface area for the reaction.

2. Consider the reaction:

$$2\,Al_{(s)} + 6\,HCl_{(aq)} \rightarrow 2\,AlCl_{3(aq)} + 3\,H_{2(g)}$$

   A 0.040 mol piece of aluminum reacted completely in 20 s. The rate of formation of hydrogen gas is

   A. 0.0013 mol/s
   B. 0.0020 mol/s
   C. 0.0030 mol/s
   D. 0.0060 mol/s

3. The activation energy of a reaction in solution

   A. increases with the addition of a catalyst.
   B. decreases with a decrease in temperature.
   C. increases if the solution is stirred vigorously.
   D. does not change with an increase in temperature.

OVER

4. Consider the following reaction mechanism:

$$\text{Step 1:} \quad NO_2 + NO_2 \rightarrow NO + NO_3$$
$$\text{Step 2:} \quad NO_3 + CO \rightarrow NO_2 + CO_2$$

The overall reaction is

A. $2NO_2 \rightarrow NO_3 + NO$
B. $NO_2 + CO \rightarrow NO + CO_2$
C. $NO_3 + CO \rightarrow NO_2 + CO_2$
D. $NO_2 + NO_3 + CO \rightarrow NO_3 + NO_2 + NO + CO_2$

5. The addition of a catalyst to a reaction provides an alternate mechanism with

A. lower activation energy and lower reaction rate.
B. lower activation energy and higher reaction rate.
C. higher activation energy and lower reaction rate.
D. higher activation energy and higher reaction rate.

6. Consider the following equilibrium:

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

Initially, a 1.0 L container is filled with 2.0 mol of NO_2. As the system approaches equilibrium, the rate of reaction of NO_2

A. increases and $[N_2O_4]$ increases.
B. increases and $[N_2O_4]$ decreases.
C. decreases and $[N_2O_4]$ increases.
D. decreases and $[N_2O_4]$ decreases.

7. Consider the following equilibrium:

$$2SO_{3(g)} \rightleftarrows 2SO_{2(g)} + O_{2(g)}$$

At equilibrium, the rate of decomposition of SO_3

A. equals the rate of formation of O_2
B. equals the rate of formation of SO_3
C. is less than the rate of formation of O_2
D. is less than the rate of formation of SO_3

8. Which of the following statements are true for all equilibrium systems?

I. Macroscopic properties are constant.
II. Mass of the reactants equals mass of the products.
III. An equilibrium can be achieved from either products or reactants.

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

9. Consider the following possible reaction:

$$N_2O_{(g)} + NO_{2(g)} \rightarrow 3NO_{(g)} \qquad \Delta H = +156 \text{ kJ}$$

Which of the following statements is correct?

A. Minimum enthalpy and maximum entropy both favour the products.
B. Minimum enthalpy and maximum entropy both favour the reactants.
C. Minimum enthalpy favours the reactants and maximum entropy favours the products.
D. Minimum enthalpy favours the products and maximum entropy favours the reactants.

10. Consider the following equilibrium:

$$2HI_{(g)} \rightleftarrows H_{2(g)} + I_{2(g)} \qquad \Delta H = -68 \text{ kJ}$$

Which of the following would cause the equilibrium to shift right?

A. Increasing the volume.
B. Decreasing the volume.
C. Increasing the temperature.
D. Decreasing the temperature.

OVER

11. Consider the following equilibrium:

$$2SO_{2(g)} + O_{2(g)} \rightleftarrows 2SO_{3(g)}$$

Which of the following will shift the equilibrium to the right?

I. adding more O_2
II. adding more SO_3
III. adding a catalyst

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

12. Consider the following equilibrium:

$$COCl_{2(g)} \rightleftarrows CO_{(g)} + Cl_{2(g)}$$

At equilibrium in a 1.0 L container, there are 3.0 mol $COCl_2$, 0.49 mol CO and 0.49 mol Cl_2. At constant temperature the volume of the above system is decreased to 0.50 L. When equilibrium is reestablished the

A. concentrations of all three gases have increased.
B. concentrations of all three gases have decreased.
C. $[COCl_2]$ has increased and $[CO]$ and $[Cl_2]$ have decreased.
D. $[COCl_2]$ has decreased and $[CO]$ and $[Cl_2]$ have increased.

13. Consider the following equilibrium:

$$N_{2(g)} + O_{2(g)} \rightleftarrows 2NO_{(g)} \qquad K_{eq} = 0.010$$

Initially, a 1.0 L container is filled with 0.40 mol of N_2, 0.10 mol of O_2 and 0.080 mol of NO. As the system approaches equilibrium the

A. $[NO]$, $[N_2]$ and $[O_2]$ remain unchanged.
B. $[NO]$ increases and both $[N_2]$ and $[O_2]$ decrease.
C. $[NO]$ decreases and both $[N_2]$ and $[O_2]$ increase.
D. $[NO]$ decreases and both $[N_2]$ and $[O_2]$ remain unchanged.

14. A saturated solution of $NiCO_3$ was evaporated to dryness. A 250.0 mL sample was found to contain 1.1×10^{-2} g $NiCO_3$. The molar mass of $NiCO_3$ is 118.7 g/mol. The molar solubility of $NiCO_3$ is

A. 9.3×10^{-5} M
B. 3.7×10^{-4} M
C. 4.4×10^{-2} M
D. 1.4×10^{-7} M

15. Which of the following has a solubility of less than 0.10 M?

A. SrS
B. $SrCl_2$
C. $SrSO_4$
D. $Sr(OH)_2$

16. A solution containing a single unknown cation is added to three test tubes. The following anions were added and observations were recorded:

TEST TUBE	ANION ADDED	OBSERVATION
1	SO_4^{2-}	precipitate
2	S^{2-}	precipitate
3	OH^-	precipitate

The solution contains

A. Sr^{2+}
B. Ag^+ or Pb^{2+}
C. Ca^{2+} or Ba^{2+}
D. K^+, NH_4^+ or H^+

OVER

17. The solubility of barium fluoride is 3.6×10^{-3} M. The solubility product constant is

A. 4.7×10^{-8}
B. 1.9×10^{-7}
C. 1.3×10^{-5}
D. 2.6×10^{-5}

18. When solutions of $Pb(NO_3)_2$ and NaCl are mixed, the trial ion product $\left(\text{Trial } K_{sp}\right)$ is 9.8×10^{-6}. Which of the following statements is true?

A. A precipitate forms because $K_{sp} > 9.8\times10^{-6}$
B. A precipitate forms because $K_{sp} < 9.8\times10^{-6}$
C. A precipitate does not form because $K_{sp} < 9.8\times10^{-6}$
D. A precipitate does not form because $K_{sp} > 9.8\times10^{-6}$

19. A student titrates a 25.00 mL sample of well water with 18.2 mL 0.100 M $AgNO_3$ to completely precipitate the chloride ion. The $\left[Cl^-\right]$ is

A. 1.82×10^{-3} M
B. 7.28×10^{-2} M
C. 1.37×10^{-1} M
D. 1.50×10^{-1} M

20. Magnesium carbonate would be most soluble in a solution of

A. $MgCl_2$
B. $NaNO_3$
C. Na_2CO_3
D. $Mg(NO_3)_2$

21. Consider the following equilibrium:

$$H_2SO_{3(aq)} + NO_2^-{}_{(aq)} \rightleftarrows HSO_3^-{}_{(aq)} + HNO_{2(aq)}$$

The NO_2^- is acting as a

A. Brönsted-Lowry acid by donating a proton.
B. Brönsted-Lowry base by donating a proton.
C. Brönsted-Lowry acid by accepting a proton.
D. Brönsted-Lowry base by accepting a proton.

22. The conjugate acid of $H_2PO_4^-$ is

A. PO_4^{3-}
B. H_3PO_4
C. HPO_4^{2-}
D. $H_3PO_4^+$

23. Consider the following equilibrium:

$$HF_{(aq)} + NH_{3(aq)} \rightleftarrows NH_4^+{}_{(aq)} + F^-{}_{(aq)}$$

Which of the following statements is true?

A. The products are favoured because HF is a stronger acid than NH_4^+
B. The products are favoured because NH_4^+ is a stronger acid than HF
C. The reactants are favoured because HF is a stronger acid than NH_4^+
D. The reactants are favoured because NH_4^+ is a stronger acid than HF

24. Which of the following is the strongest base in water?

A. OH^-
B. H_2O
C. NH_3
D. HO_2^-

OVER

25. An amphiprotic substance can act as

A. a base only.
B. an acid only.
C. both an acid and a base.
D. neither an acid nor a base.

26. Which of the following is the weakest acid?

A. HCOOH
B. C_6H_5OH
C. $H_3C_6H_5O_7$
D. CH_3COOH

27. The hydrogen oxalate ion, $HC_2O_4^-$, is amphiprotic.

$$K_a = 6.4 \times 10^{-5}$$
$$K_b = 1.7 \times 10^{-13}$$

The predominant reaction is

A. $HC_2O_4^- + H_2O \rightleftarrows OH^- + H_2C_2O_4$ because $K_a < K_b$
B. $HC_2O_4^- + H_2O \rightleftarrows H_3O^+ + C_2O_4^{2-}$ because $K_a < K_b$
C. $HC_2O_4^- + H_2O \rightleftarrows OH^- + H_2C_2O_4$ because $K_a > K_b$
D. $HC_2O_4^- + H_2O \rightleftarrows H_3O^+ + C_2O_4^{2-}$ because $K_a > K_b$

28. List the following 1.0 M solutions in order of decreasing pH.

$CaBr_2$ $FeCl_3$ NaF

A. $NaF > CaBr_2 > FeCl_3$
B. $FeCl_3 > CaBr_2 > NaF$
C. $CaBr_2 > NaF > FeCl_3$
D. $FeCl_3 > NaF > CaBr_2$

29. A beaker contains 200.0 mL of 0.40 M HNO_3. The calculation for pH is

A. $\text{pH} = -\log(0.40\ \text{M})$

B. $\text{pH} = -\log(10^{-14} \div 0.40\ \text{M})$

C. $\text{pH} = -\log(0.40\ \text{M} \times 0.200\ \text{L})$

D. $\text{pH} = -\log(0.40\ \text{M} \div 0.200\ \text{L})$

30. Which of the following statements concerning pK_w are true?

I. $pK_w = -\log K_w$

II. $pK_w = \text{pH} + \text{pOH}$

III. $pK_w = \left[H_3O^+\right]\left[OH^-\right]$

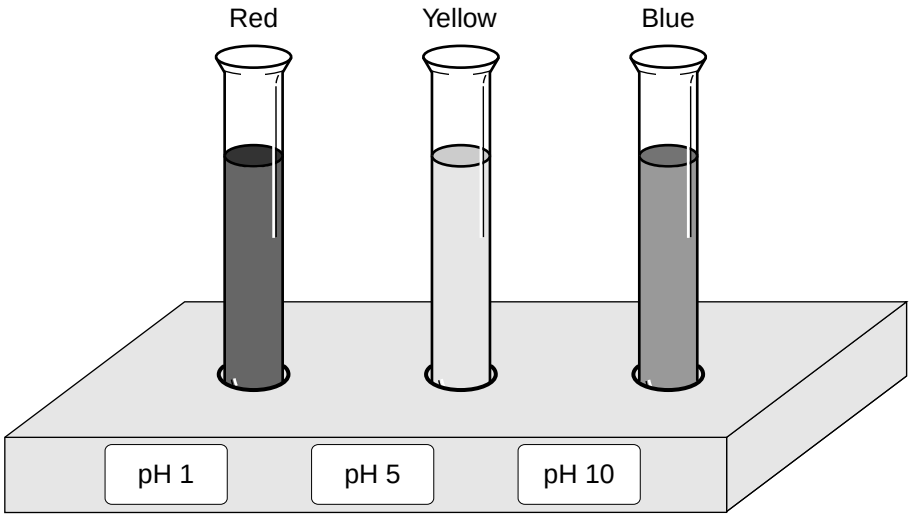
A. I and II only
B. I and III only
C. II and III only
D. I, II and III

31. A students adds 10.0 mL of 1.0 M $HClO_4$ into 990.0 mL of water. The pH of the solution has changed by

A. 0.01
B. 1
C. 2
D. 100

OVER

32. An indicator was added to solutions of different pH and the following was observed:



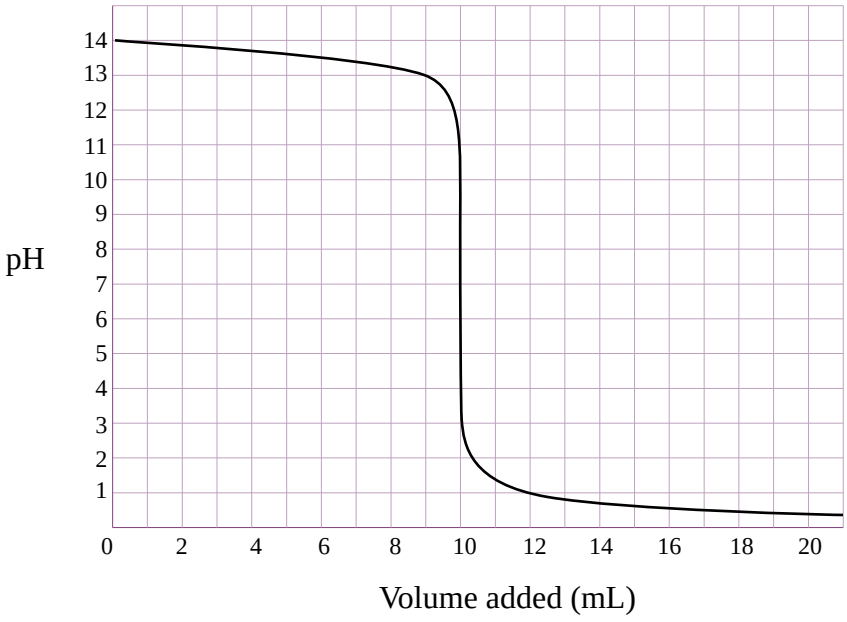
The indicator is

A. methyl red.
B. thymol blue.
C. methyl orange.
D. bromthymol blue.

33. Which of the following solutions **should** be used when titrating a 25.00 mL sample of CH_3COOH that is approximately 0.1 M?

A. 0.150 M NaOH
B. 0.001 M NaOH
C. 3.00 M NaOH
D. 6.00 M NaOH

34. Consider the following titration curve:



This curve represents the titration of a

A. strong base by adding a weak acid.
B. strong acid by adding a weak base.
C. strong acid by adding a strong base.
D. strong base by adding a strong acid.

35. What volume of 0.250 M H_2SO_4 is required to neutralize 25.00 mL of 2.50 M KOH?

A. 125 mL
B. 150 mL
C. 250 mL
D. 500 mL

36. Which of the following pairs of substances form a buffer system for human blood?

A. HCl and Cl^-
B. NH_3 and NH_2^-
C. H_2CO_3 and HCO_3^-
D. $H_3C_6H_5O_7$ and $HC_6H_5O_7^{2-}$

OVER

Use the following redox reaction to answer questions 37 and 38.

$$MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$$

37. During the reaction, electrons transfer from

A. Fe^{3+} to Fe^{2+}
B. Fe^{2+} to MnO_4^-
C. MnO_4^- to Fe^{2+}
D. MnO_4^- to Mn^{2+}

38. The oxidizing agent in the above reaction is

A. Fe^{2+}
B. Fe^{3+}
C. Mn^{2+}
D. MnO_4^-

---

39. A solution of 1.0 M $Pb(NO_3)_2$ will not react with a container made of

A. Cu
B. Fe
C. Sn
D. Zn

40. Consider the following half-reaction:

$$Sb_2O_3 + 6H^+ + 6e^- \rightleftarrows 2Sb + 3H_2O$$

The oxidation number of antimony in Sb_2O_3

A. increases by 3.
B. increases by 6.
C. decreases by 3.
D. decreases by 6.

41. As an element is oxidized, its oxidation number

A. increases as electrons are lost.
B. decreases as electrons are lost.
C. increases as electrons are gained.
D. decreases as electrons are gained.

42. Consider the following unbalanced half-reaction:

$$HClO_2 \rightleftarrows HClO$$

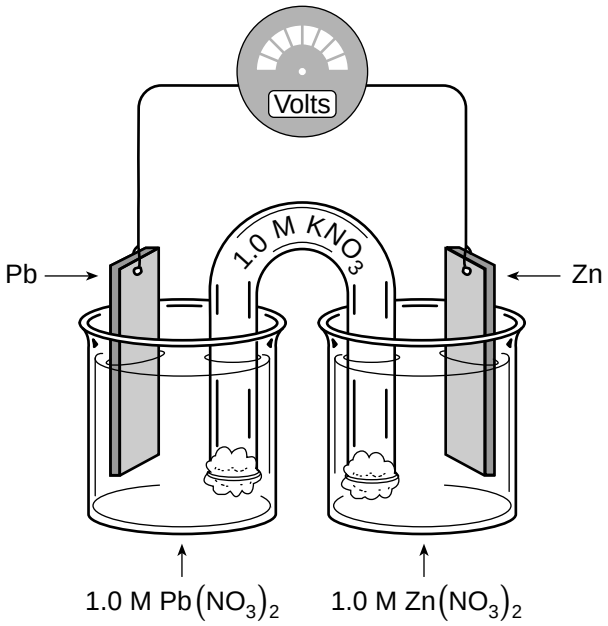
The balanced half-reaction would have

A. 1 electron on the left.
B. 1 electron on the right.
C. 2 electrons on the left.
D. 2 electrons on the right.

43. The direction of electron flow in an electrochemical cell is from

A. anode to cathode through the external wire.
B. cathode to anode through the external wire.
C. anode to cathode through the external wire and back through the salt bridge.
D. cathode to anode through the external wire and back through the salt bridge.

Use the following diagram to answer questions 44 to 46.



44. In an operating lead-zinc electrochemical cell, the cathode

A. gains mass as anions are reduced.
B. loses mass as anions are reduced.
C. gains mass as cations are reduced.
D. loses mass as cations are reduced.

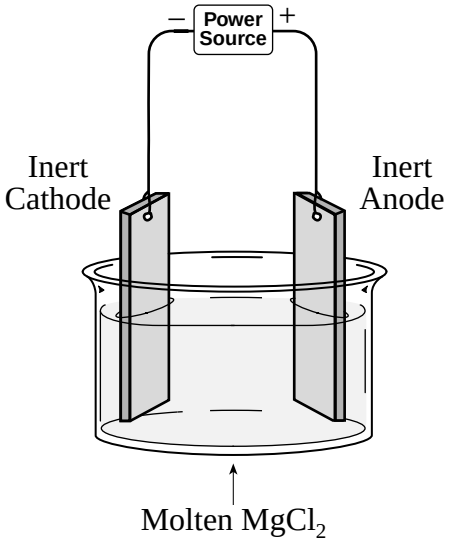
45. The initial cell voltage is

A. -0.89
B. -0.63
C. $+0.63$
D. $+0.89$

46. The equation for the half-reaction at the anode is

A. $Zn^{2+} + 2e^- \rightarrow Zn$
B. $Pb^{2+} + 2e^- \rightarrow Pb$
C. $Zn \rightarrow Zn^{2+} + 2e^-$
D. $Pb \rightarrow Pb^{2+} + 2e^-$

47. Consider the following electrolytic cell:



As this cell operates,

A. Cl^- is oxidized at the anode.
B. Mg^{2+} is oxidized at the anode.
C. Cl^- is oxidized at the cathode.
D. Mg^{2+} is oxidized at the cathode.

48. Electroplating **always** involves the

A. oxidation of anions.
B. reduction of cations.
C. reduction at the anode.
D. oxidation at the cathode.

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

OVER

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. A strip of magnesium was cut into 4 pieces, each of length 1.0 cm and mass of 0.00864 g. Each piece was placed into a test tube containing 5.0 mL of different concentrations of HCl. The time required for each piece of magnesium to be completely consumed was recorded:

TRIAL	[HCl]	TIME (s)
1	0.50 M	200
2	1.0 M	38
3	3.0 M	12
4	6.0 M	6

a) Calculate the rate of reaction for magnesium in 3.0 M HCl. **(1 mark)**

b) How does the [HCl] affect the reaction rate? **(1 mark)**

_____

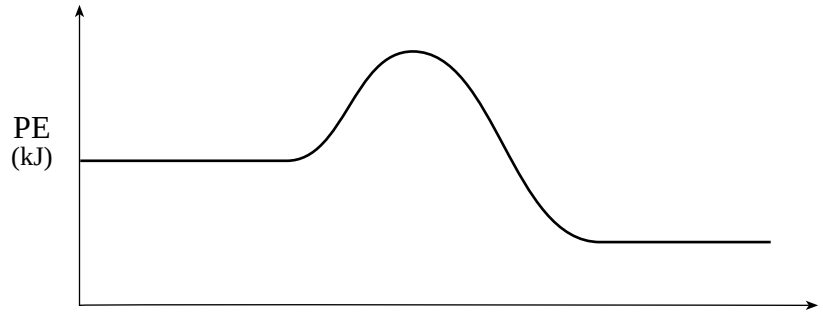
_____

Score for Question 1:

1. _____ (2)

2. Consider the following PE diagram for the uncatalyzed decomposition of hydrogen peroxide:

$$2H_2O_{2(\ell)} \rightarrow 2H_2O_{(\ell)} + O_{2(g)}$$



a) On the PE diagram, sketch a curve for the catalyzed decomposition of H_2O_2. **(1 mark)**

b) Compare the ΔH of the catalyzed and uncatalyzed reactions. **(1 mark)**

_____

Score for Question 2:

2. _____ (2)

3. Consider the following equilibrium:

$$PCl_{3(g)} + Cl_{2(g)} \rightleftarrows PCl_{5(g)} \qquad \Delta H = -88 \text{ kJ}$$

What happens to the $[PCl_3]$ when additional Cl_2 is added at constant temperature and volume? Explain. **(2 marks)**

_____

_____

Score for Question 3:

3. _____ (2)

OVER

4. Consider the following equilibrium:

$$2CO_{2(g)} \rightleftarrows 2CO_{(g)} + O_{2(g)}$$

Initially, a 1.0 L container is filled with 0.050 mol of CO_2. At equilibrium, the $[CO_2]$ is $0.030\,\text{mol/L}$. Calculate the value of K_{eq}. **(3 marks)**

Score for Question 4:
4. _____ (3)

5. a) Identify a compound that could be used to precipitate both the $Mg^{2+}_{(aq)}$ and $Ca^{2+}_{(aq)}$ from "hard water". **(1 mark)**

b) Write the net ionic equations for the reactions. **(2 marks)**

Score for Question 5:
5. _____ (3)

6. How many grams of $CaSO_4$ (Plaster of Paris) are dissolved in 100.0 mL of a saturated $CaSO_4$ solution at $25°C$? **(3 marks)**

Score for Question 6:

6. _____ (3)

7. Lactic acid, $HC_3H_5O_3$, is a compound that accumulates in muscle tissue during exertion. Write the equation and the K_a expression for the ionization of lactic acid in water. **(2 marks)**

Score for Question 7:

7. _____ (2)

OVER

8. The ionization constant for water, K_w, is 9.6×10^{-14} at $60°C$.

a) Write an equation including the heat term representing the ionization of water. **(2 marks)**

b) Calculate the pH for water at $60°C$. **(2 marks)**

Score for Question 8:
8. _____ (4)

9. Four monoprotic acids of the same concentration are labelled as follows:

SOLUTION	LABEL
A	$[OH^-] = 5.0 \times 10^{-11}$ M
B	$[H^+] = 0.20$ M
C	pOH = 11.30 M
D	pH = 1.20 M

List the four solutions in order of decreasing acidity. Use calculations to support your answer. **(4 marks)**

Score for Question 9:
9. _____ (4)

10. a) Write the balanced equation for the redox reaction that occurs when $H_2S_{(g)}$ is bubbled into an acidified solution of $Cr_2O_7^{2-}$. **(3 marks)**

b) Calculate the $E°$ for this reaction. **(1 mark)**

Score for Question 10:

10. _____ (4)

11. The metals A, B and C were separately placed in solutions containing the metallic ions A^{2+}, B^{+} and C^{2+}. It was found that A reacted with B^{+}, but A did not react with C^{2+}.

a) Identify the strongest oxidizing agent. **(1 mark)**

b) List the metals in order of increasing strength as reducing agents. **(1 mark)**

c) Identify the ion(s) that will react with metal C. **(1 mark)**

Score for Question 11:

11. _____ (3)

END OF EXAMINATION