JANUARY 2000 – CHEMISTRY 12 PROVINCIAL EXAM

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 is most likely to have the **greatest** reaction rate at room temperature?

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

   B. $2Ag^{+}_{(aq)} + CrO_4^{2-}{}_{(aq)} \rightarrow Ag_2CrO_{4(s)}$

   C. $Pb_{(s)} + 2HCl_{(aq)} \rightarrow PbCl_{2(aq)} + H_{2(g)}$

   D. $CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$

2. Consider the following reaction involving 1.0 g of powdered zinc:

$$Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$$

Trial	Temperature (°C)	Concentration of HCl
1	40	3.0
2	20	3.0
3	40	6.0

   The rates, in order of fastest to slowest, are

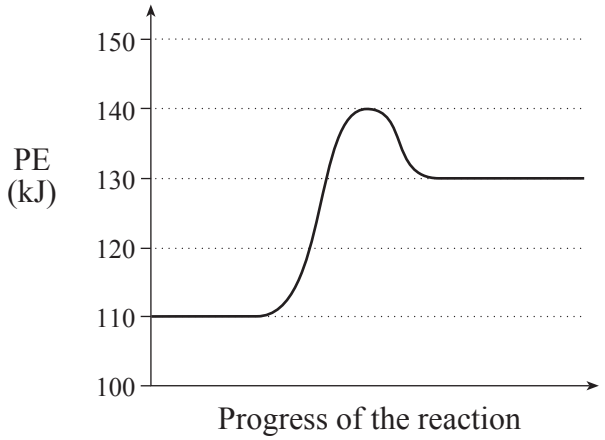
   A. 1, 2, 3
   B. 2, 1, 3
   C. 3, 1, 2
   D. 3, 2, 1

3. Activation energy can be described as the

   A. energy of motion.
   B. energy of the activated complex.
   C. energy difference between the reactants and the products.
   D. energy difference between the reactants and the activated complex.

OVER

4. Consider the following potential energy diagram for a reversible reaction:



Which of the following describes the system above?

	Reaction	Activation Energy (kJ)	ΔH (kJ)
A.	reverse	10	–20
B.	reverse	10	–30
C.	forward	30	+10
D.	forward	20	+30

5. Increasing the temperature of a reaction increases the reaction rate by

I.	increasing frequency of collisions
II.	increasing the kinetic energy of collision
III.	decreasing the potential energy of collision

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

6. What effect does a catalyst have on a reaction?

   A. It changes the ΔH of a reaction.
   B. It increases the kinetic energy of the reactants.
   C. It decreases the potential energy of the products.
   D. It provides a reaction mechanism with a lower activation energy.

7. Consider the following equilibrium:

$$N_{2(g)} + 2O_{2(g)} \rightleftarrows 2NO_{2(g)}$$

   Equal moles of N_2 and O_2 are added, under certain conditions, to a closed container. Which of the following describes the changes in the reverse reaction which occur as the system proceeds toward equilibrium?

	Rate of Reverse Reaction	$[NO_2]$
A.	increases	increases
B.	decreases	increases
C.	increases	decreases
D.	decreases	decreases

8. A chemical equilibrium is described as "dynamic" because

   A. maximum randomness has been achieved.
   B. the pressure and temperature do not change.
   C. both reactants and products continue to form.
   D. the concentrations of chemical species remain constant.

9. Which of the following reactions results in an entropy increase?

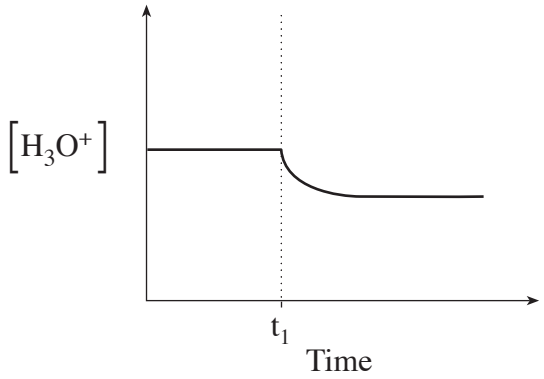
   A. $2C_{(s)} + O_{2(g)} \rightarrow 2CO_{(g)}$
   B. $N_{2(g)} + 2H_{2(g)} \rightarrow N_2H_{4(\ell)}$
   C. $2SO_{2(g)} + O_{2(g)} \rightarrow 2SO_{3(g)}$
   D. $Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)}$

OVER

10. Consider the following equilibrium:

$$CH_3COOH_{(aq)} + H_2O_{(\ell)} \rightleftarrows CH_3COO^-_{(aq)} + H_3O^+_{(aq)} + \text{heat}$$

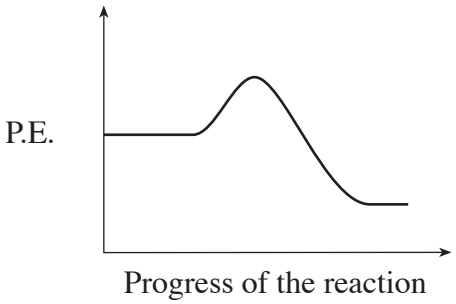
A stress was applied at time t_1 and the data was plotted on the following graph:



The stress that was imposed at time t_1 is the result of

A. the addition of HCl.
B. decreasing the temperature.
C. the addition of $NaCH_3COO$.
D. increasing the volume of the container.

11. Consider the following potential energy diagram for an equilibrium system:



When the temperature of the system is increased, the equilibrium shifts to the

A. left and the K_{eq} increases.
B. left and the K_{eq} decreases.
C. right and the K_{eq} increases.
D. right and the K_{eq} decreases.

12. What is the K_{eq} expression for the following equilibrium?

$$3Fe_{(s)} + 4H_2O_{(g)} \rightleftarrows Fe_3O_{4(s)} + 4H_{2(g)}$$

A. $K_{eq} = [H_2]^4$

B. $K_{eq} = \dfrac{[H_2]}{[H_2O]}$

C. $K_{eq} = \dfrac{[H_2]^4}{[H_2O]^4}$

D. $K_{eq} = \dfrac{[Fe_3O_4][H_2]^4}{[Fe]^3[H_2O]^4}$

13. Consider the following equilibrium:

$$2O_{3(g)} \rightleftarrows 3O_{2(g)} \qquad K_{eq} = 65$$

Initially, 0.10 mole of O_3 and 0.10 mole of O_2 are placed in a 1.0 L container. Which of the following describes the changes in concentrations as the reaction proceeds toward equilibrium?

	$[O_3]$	$[O_2]$
A.	decreases	decreases
B.	decreases	increases
C.	increases	decreases
D.	increases	increases

14. Which of the following does **not** define solubility?

A. the concentration of solute in a saturated solution
B. the moles of solute dissolved in a given volume of solution
C. the maximum mass of solute that can dissolve in a given volume of solution
D. the minimum moles of solute needed to produce one litre of a saturated solution

OVER

15. The ion concentrations in $0.25\,M\ Al_2(SO_4)_3$ are

	$[Al^{3+}]$	$[SO_4{}^{2-}]$
A.	0.25 M	0.25 M
B.	0.50 M	0.75 M
C.	0.75 M	0.50 M
D.	0.10 M	0.15 M

16. Which of the following will **not** produce a precipitate when equal volumes of $0.20\,M$ solutions are combined?

A. KOH and $CaCl_2$

B. $Zn(NO_3)_2$ and K_3PO_4

C. $Sr(OH)_2$ and $(NH_4)_2S$

D. Na_2SO_4 and $Pb(NO_3)_2$

17. What is observed when H_2SO_4 is added to a saturated solution of $CaSO_4$?

A. the pH increases

B. the $[Ca^{2+}]$ increases

C. bubbles of H_2 are given off

D. additional $CaSO_4$ precipitates

18. The solubility of $CdS = 2.8 \times 10^{-14}$. The value of K_{sp} is

A. 7.8×10^{-28}

B. 2.8×10^{-14}

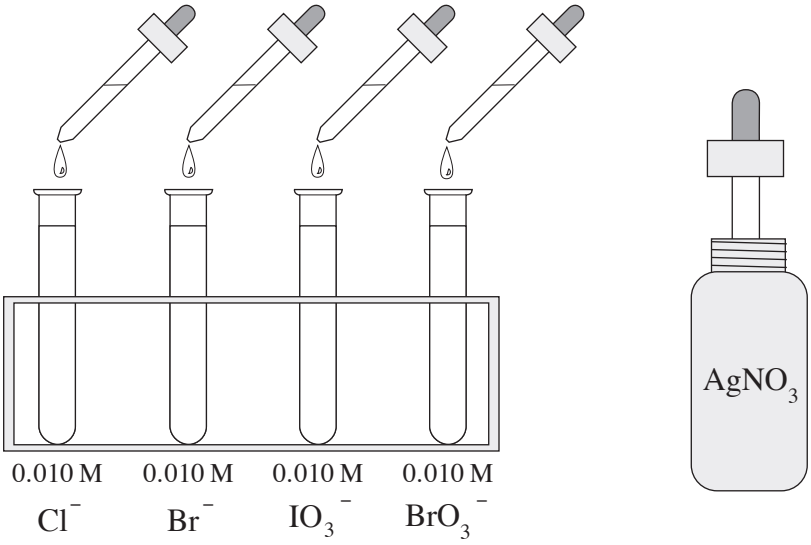
C. 5.6×10^{-14}

D. 1.7×10^{-7}

19. How many moles of solute are dissolved in 200.0 mL of a saturated solution of FeS?

A. 1.2×10^{-19}
B. 6.0×10^{-19}
C. 1.5×10^{-10}
D. 7.7×10^{-10}

20. Consider the following 10.0 mL solutions:



Equal moles of $AgNO_3$ are added to each solution. It is observed that a precipitate forms in all but one solution. Which solution does **not** form a precipitate?

A. Cl^-
B. Br^-
C. IO_3^-
D. BrO_3^-

21. Which of the following could dissolve a precipitate of CaC_2O_4 in a saturated solution of CaC_2O_4 ?

A. NaOH
B. CaC_2O_4
C. $H_2C_2O_4$
D. $Ca(NO_3)_2$

OVER

22. Which of the following is a general property of bases?

A. taste sour
B. turn litmus red
C. conduct electric current in solution
D. concentration of H_3O^+ is greater than concentration of OH^-

23. Water will act as an acid with which of the following?

I.	H_2CO_3
II.	HCO_3^-
III.	CO_3^{2-}

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

24. Which of the following 1.0 M solutions will have the greatest electrical conductivity?

A. HI
B. H_2S
C. HCN
D. H_3PO_4

25. An acid is added to water and a new equilibrium is established.
The new equilibrium can be described by

A. pH < pOH and $K_w = 1 \times 10^{-14}$
B. pH < pOH and $K_w < 1 \times 10^{-14}$
C. pH > pOH and $K_w = 1 \times 10^{-14}$
D. pH > pOH and $K_w > 1 \times 10^{-14}$

26. Consider the following equilibrium:

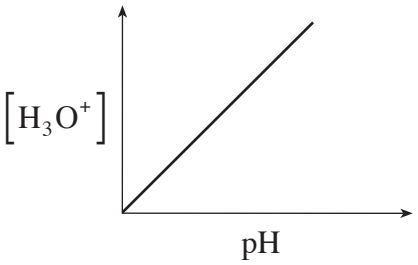
$$2H_2O_{(\ell)} + \text{energy} \rightleftarrows H_3O^+_{(aq)} + OH^-_{(aq)}$$

The $\left[H_3O^+\right]$ will decrease and the K_w will remain constant when

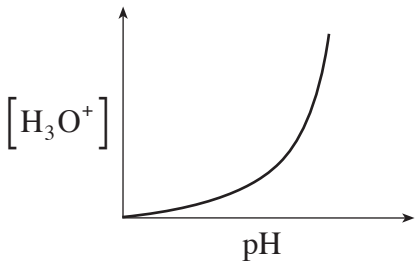
A. a strong acid is added.
B. a strong base is added.
C. the temperature is increased.
D. the temperature is decreased.

27. Which of the following graphs describes the relationship between $\left[H_3O^+\right]$ and pH ?

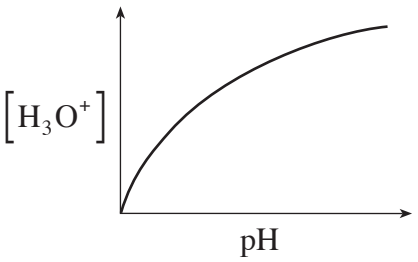
A.



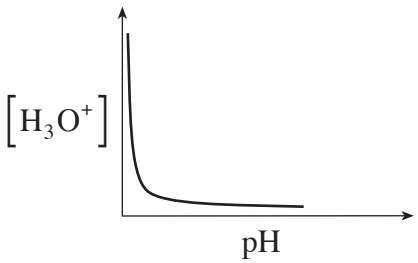
B.



C.



D.



28. When the $\left[H_3O^+\right]$ in a solution is increased to twice the original concentration, the change in pH could be from

A. 1.7 to 1.4
B. 2.0 to 4.0
C. 5.0 to 2.5
D. 8.5 to 6.5

OVER

29. The relationship $\frac{\left[H_2P_2O_7^{2-}\right]\left[H_3O^+\right]}{\left[H_3P_2O_7^-\right]}$ is the

A. K_a for $H_3P_2O_7^-$
B. K_b for $H_3P_2O_7^-$
C. K_a for $H_2P_2O_7^{2-}$
D. K_b for $H_2P_2O_7^{2-}$

30. Which of the following describes the relationship between acid strength and K_a value for weak acids?

	Acid Strength	K_a
A.	increases	increases
B.	increases	decreases
C.	decreases	increases
D.	decreases	remains constant

31. The value of K_b for HPO_4^{2-} is

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

32. Which of the following 1.0 M solutions would have a pH greater than 7.00?

A. HCN
B. KNO_3
C. NH_4Cl
D. $NaCH_3COO$

33. What is the pH at the transition point for an indicator with a K_a of 2.5×10^{-4} ?

A. 2.5×10^{-4}
B. 3.60
C. 7.00
D. 10.40

34. What volume of 0.100 M NaOH is required to completely neutralize 15.00 mL of 0.100 M H_3PO_4 ?

A. 5.00 mL
B. 15.0 mL
C. 30.0 mL
D. 45.0 mL

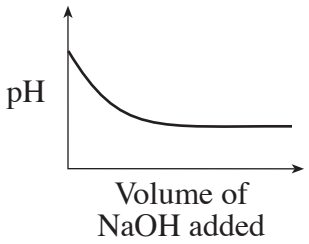
35. What is the pH of the solution formed when 0.060 moles NaOH is added to 1.00 L of 0.050 M HCl?

A. 2.00
B. 7.00
C. 12.00
D. 12.78

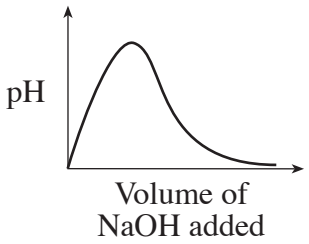
OVER

36. Which of the following graphs describes the relationship between the pH of a buffer and the volume of NaOH added to the buffer?

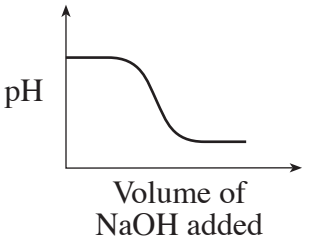
A.



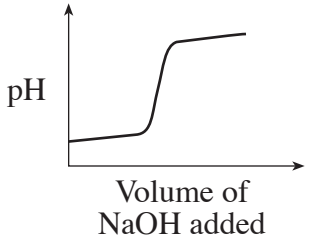
B.



C.



D.



37. A gas which is produced by internal combustion engines and contributes to the formation of acid rain is

A. H_2
B. O_3
C. CH_4
D. NO_2

38. Which of the following represents a redox reaction?

A. $CaCO_3 \rightarrow CaO + CO_2$
B. $SiCl_4 + 2Mg \rightarrow Si + 2MgCl_2$
C. $2NaOH + H_2SO_4 \rightarrow 2H_2O + Na_2SO_4$
D. $AgBr + 2S_2O_3^{2-} \rightarrow Ag(S_2O_3)_2^{3-} + Br^-$

39. Consider the following reaction:

$$TiCl_4 + O_2 \rightarrow TiO_2 + 2Cl_2$$

Each oxygen atom is

A. reduced and loses $2e^-$
B. reduced and gains $2e^-$
C. oxidized and loses $2e^-$
D. oxidized and gains $2e^-$

40. When NO_2 acts as a reducing agent, a possible product is

A. NO
B. N_2O
C. N_2O_4
D. N_2O_5

41. Which of the following 1.0 M solutions will react spontaneously with lead?

A. KCl
B. $CuCl_2$
C. $ZnCl_2$
D. $MgCl_2$

42. Consider the following redox reaction:

$$I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^-$$

In a titration, 40.00 mL of $Na_2S_2O_3$ is needed to react completely with 4.0×10^{-3} mol I_2. What is the concentration of $Na_2S_2O_3$?

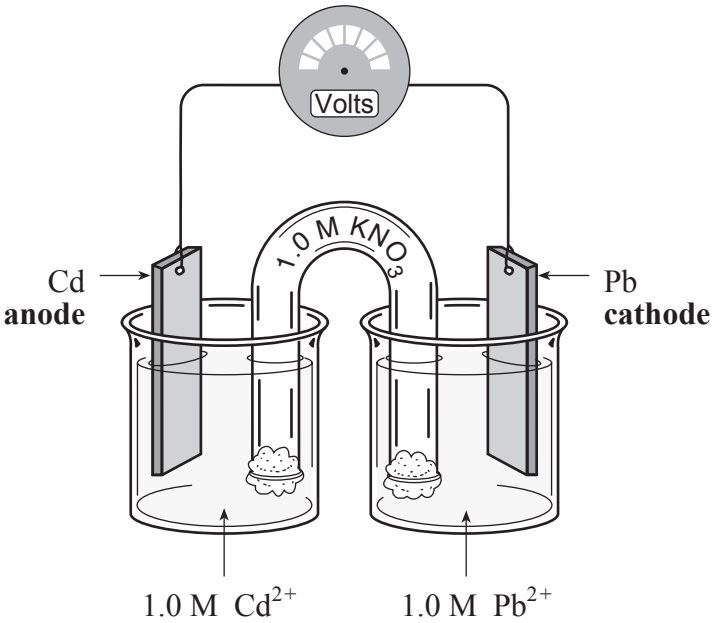
A. 0.10 M
B. 0.16 M
C. 0.20 M
D. 0.32 M

OVER

43. In an operating electrochemical cell the function of a salt bridge is to

A. allow hydrolysis to occur.
B. allow a non-spontaneous reaction to occur.
C. permit the migration of ions within the cell.
D. transfer electrons from the cathode to the anode.

Use the following diagram to answer questions 44 and 45.



E° cell = 0.27 V

44. As the cell operates, electrons flow toward

A. the Pb electrode, where Pb is oxidized.
B. the Cd electrode, where Cd is oxidized.
C. the Pb electrode, where Pb^{2+} is reduced.
D. the Cd electrode, where Cd^{2+} is reduced.

45. The E° value for the reduction of Cd^{2+} is

A. −0.40 V
B. −0.27 V
C. +0.14 V
D. +0.40 V

46. The following reaction occurs in an electrochemical cell:

$$3Cu^{2+} + 2Cr \rightarrow 2Cr^{3+} + 3Cu$$

The $E°$ for the cell is

A. 0.40 V
B. 0.75 V
C. 1.08 V
D. 2.50 V

47. During the corrosion of magnesium, the anode reaction is

A. $Mg \rightarrow Mg^{2+} + 2e^-$
B. $Mg^{2+} + 2e^- \rightarrow Mg$
C. $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$
D. $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

48. A molten binary salt, $ZnCl_2$, undergoes electrolysis. The cathode reaction is

A. $Zn \rightarrow Zn^{2+} + 2e^-$
B. $2Cl^- \rightarrow Cl_2 + 2e^-$
C. $Cl_2 + 2e^- \rightarrow 2Cl^-$
D. $Zn^{2+} + 2e^- \rightarrow Zn$

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 student wishes to monitor the rate of the following reaction:

$$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(\ell)}$$

Identify **two** different properties that could be used to monitor the rate of the reaction. Describe and explain the changes that would occur. **(2 marks)**

Property 1: _____

Change and Explanation: _____

_____

Property 2: _____

Change and Explanation: _____

_____

2. Consider the following reaction for the formation of HCl in the presence of light.

$$Cl_2 + CHCl_3 \rightarrow HCl + CCl_4$$

The following is the proposed reaction mechanism:

Step 1	$Cl_2 \rightarrow Cl + Cl$
Step 2	**?**
Step 3	$Cl + CCl_3 \rightarrow CCl_4$

Determine Step 2 of the reaction mechanism. **(2 marks)**

3. Consider the following equilibrium:

$$\underset{\text{(yellow)}}{HInd} + H_2O \rightleftarrows H_3O^+ + \underset{\text{(blue)}}{Ind^-}$$

The system is yellow and turns blue on the addition of NaOH. In terms of the forward and reverse reaction rates, explain why this shift occurs. **(2 marks)**

_____

_____

_____

_____

_____

OVER

4. Consider the following equilibrium:

$$Fe^{3+}_{(aq)} + SCN^{-}_{(aq)} \rightleftarrows FeSCN^{2+}_{(aq)}$$

Initially, 50.0 mL of 0.10 M Fe^{3+} is added to 30.0 mL of 0.20 M SCN^{-}.
At equilibrium, the concentration of $FeSCN^{2+}$ is found to be 0.050 M.
Calculate the K_{eq} for the reaction. **(4 marks)**

5. a) Write the balanced formula equation for the reaction between $Na_3PO_{4(aq)}$ and $CuCl_{2(aq)}$. **(1 mark)**

b) Write the net ionic equation for the reaction between $Na_3PO_{4(aq)}$ and $CuCl_{2(aq)}$. **(1 mark)**

6. A saturated solution of nickel carbonate, $NiCO_3$, contains 0.090 g in 2.0 L of solution. Calculate K_{sp} for $NiCO_3$. **(3 marks)**

7. Define the term *amphiprotic*. Give an example of an ion which is amphiprotic. **(2 marks)**

Definition: _____

_____

Example: _____

OVER

8. A $0.0200\,M$ solution of methylamine, CH_3NH_2, has a $pH = 11.40$.
Calculate the K_b for methylamine. **(4 marks)**

9. A titration was performed by adding $0.115\,M$ NaOH to a $25.00\,mL$ sample of H_2SO_4.
Calculate the $[H_2SO_4]$ from the following data. **(3 marks)**

	Trial #1	Trial #2	Trial #3
Initial volume of NaOH(mL)	4.00	17.05	8.00
Final volume of NaOH(mL)	17.05	28.00	19.05

10. a) Indicate in the blank spaces on the following chart whether or not a reaction will occur when the metals are added to aqueous ions. **(1 mark)**

metal / ion	Pd	Rh	Pt
Pd^{2+}			
Rh^{2+}	no reaction		no reaction
Pt^{2+}	reaction	reaction	

b) List the oxidizing agents in order of strongest to weakest. **(1 mark)**

OVER

11. Balance the following redox reaction in **basic** solution: **(4 marks)**

$$Au + Cl^- + O_2 \rightarrow AuCl_4^- + OH^- \qquad \text{(basic)}$$

12. Draw and label a simple electrolytic cell capable of electroplating an inert electrode with silver.
(2 marks)

END OF EXAMINATION

Chemistry 12

January 2000 Provincial Examination

ANSWER KEY / SCORING GUIDE

CURRICULUM:

Organizers	Sub-Organizers
1. Reaction Kinetics	A, B, C
2. Dynamic Equilibrium	D, E, F
3. Solubility Equilibria	G, H, I
4. Acids, Bases, and Salts	J, K, L, M, N, O, P, Q, R
5. Oxidation – Reduction	S, T, U, V, W

Part A: Multiple Choice

Q	K	C	CO	PLO	Q	K	C	CO	PLO
1.	B	U	1	A1	25.	A	H	4	L3
2.	C	U	1	A6	26.	B	U	4	L3, L6
3.	D	K	1	B3	27.	D	H	4	L11
4.	A	U	1	B6	28.	A	U	4	L12
5.	B	U	1	B9	29.	A	K	4	M1
6.	D	K	1	C3	30.	A	K	4	M2
7.	A	U	2	D3	31.	C	U	4	M4
8.	C	K	2	D5	32.	D	U	4	N3
9.	A	U	2	D7	33.	B	U	4	O4
10.	C	H	2	E2	34.	D	U	4	P3
11.	B	U	2	E2	35.	C	U	4	P5
12.	C	K	2	F2	36.	D	H	4	Q5
13.	B	U	2	F8	37.	D	K	4	R4
14.	B	K	3	G3	38.	B	U	5	S1
15.	B	U	3	G8	39.	B	U	5	S1
16.	C	U	3	H2	40.	D	U	5	S2
17.	D	H	3	H5	41.	B	U	5	S6
18.	A	U	3	I3	42.	C	U	5	T6
19.	C	U	3	I4	43.	C	K	5	U1
20.	D	U	3	I5	44.	C	U	5	U2, U4
21.	A	H	3	H5	45.	A	U	5	U7
22.	C	K	4	J2	46.	C	U	5	U9
23.	D	U	4	J8, N4	47.	A	K	5	V2
24.	A	U	4	K1, K6	48.	D	K	5	W2

Multiple Choice = 48 marks

Part B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	2	1	A4
2.	2	H	2	1	C2
3.	3	U	2	2	E3
4.	4	U	4	2	F6
5.	5	U	2	3	H3
6.	6	U	3	3	I7
7.	7	K	2	4	K10, K11
8.	8	U	4	4	M5
9.	9	U	3	4	P2
10.	10	U	2	5	S4
11.	11	U	4	5	T2
12.	12	U	2	5	W6

Written Response = 32 marks

Multiple Choice = 48 (48 questions)
Written Response = 32 (12 questions)
EXAMINATION TOTAL = 80 marks

LEGEND:

Q = Question Number **K** = Keyed Response **C** = Cognitive Level
B = Score Box Number **S** = Score **CO** = Curriculum Organizer
PLO = Prescribed Learning Outcome

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 student wishes to monitor the rate of the following reaction:

$$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(\ell)}$$

Identify **two** different properties that could be used to monitor the rate of the reaction. Describe and explain the changes that would occur. **(2 marks)**

Solution:

For Example:

Property: Mass ← $\frac{1}{2}$ **mark**

Change and Explanation: Mass decreases because $CO_{2(g)}$ leaves the system. ← $\frac{1}{2}$ **mark**

Property: pH ← $\frac{1}{2}$ **mark**

Change and Explanation: pH increases because HCl is consumed. ← $\frac{1}{2}$ **mark**

2. Consider the following reaction for the formation of HCl in the presence of light.

$$Cl_2 + CHCl_3 \rightarrow HCl + CCl_4$$

The following is the proposed reaction mechanism:

Step 1	$Cl_2 \rightarrow Cl + Cl$
Step 2	**?**
Step 3	$Cl + CCl_3 \rightarrow CCl_4$

Determine Step 2 of the reaction mechanism. **(2 marks)**

Solution:

$Cl + CHCl_3 \rightarrow HCl + CCl_3$ ← **2 marks**

3. Consider the following equilibrium:

$$\underset{\text{(yellow)}}{\text{HInd}} + H_2O \rightleftarrows H_3O^+ + \underset{\text{(blue)}}{Ind^-}$$

The system is yellow and turns blue on the addition of NaOH. In terms of the forward and reverse reaction rates, explain why this shift occurs. **(2 marks)**

Solution:

For Example:

Addition of OH^- decreases $\left[H_3O^+\right]$, decreasing the reverse rate. Since the forward rate is greater than the reverse rate, the system shifts to the right. } ← **2 marks**

4. Consider the following equilibrium:

$$Fe^{3+}_{(aq)} + SCN^{-}_{(aq)} \rightleftarrows FeSCN^{2+}_{(aq)}$$

Initially, 50.0 mL of 0.10 M Fe^{3+} is added to 30.0 mL of 0.20 M SCN^{-}.
At equilibrium, the concentration of $FeSCN^{2+}$ is found to be 0.050 M.
Calculate the K_{eq} for the reaction. **(4 marks)**

Solution:

For Example:

$$\left[Fe^{3+}\right] = \frac{50.0\text{ mL}}{80.0\text{ mL}} \times 0.10\text{ M} = 0.0625\text{ M}$$

$$\left[SCN^{-}\right] = \frac{30.0\text{ mL}}{80.0\text{ mL}} \times 0.20\text{ M} = 0.0750\text{ M}$$

← **1 mark**

	Fe^{3+}	+ SCN^{-}	$\rightleftarrows$ $FeSCN^{2+}$
[I]	0.0625	0.0750	0
[C]	−0.0500	−0.0500	0.0500
[E]	0.0125	0.0250	0.0500

← **1 $\frac{1}{2}$ marks**

$$K_{eq} = \frac{\left[FeSCN^{2+}\right]}{\left[Fe^{3+}\right]\left[SCN^{-}\right]}$$

$$= \frac{0.0500}{(0.0125)(0.0250)}$$

$$= 1.6 \times 10^{2}$$

← **1 $\frac{1}{2}$ marks**

5. a) Write the balanced formula equation for the reaction between $Na_3PO_{4(aq)}$ and $CuCl_{2(aq)}$.

(1 mark)

Solution:

$$2Na_3PO_{4(aq)} + 3CuCl_{2(aq)} \rightarrow 6NaCl_{(aq)} + Cu_3(PO_4)_{2(s)}$$ ← **1 mark**

b) Write the net ionic equation for the reaction between $Na_3PO_{4(aq)}$ and $CuCl_{2(aq)}$. **(1 mark)**

Solution:

$$3Cu^{2+}_{(aq)} + 2PO_4^{3-}{}_{(aq)} \rightarrow Cu_3(PO_4)_{2(s)}$$ ← **1 mark**

6. A saturated solution of nickel carbonate, $NiCO_3$, contains 0.090 g in 2.0 L of solution. Calculate K_{sp} for $NiCO_3$. **(3 marks)**

Solution:

$$\left[NiCO_3\right] = \frac{0.090\,g}{2.0\,L} \times \frac{1\,mol}{118.7\,g} = 3.79 \times 10^{-4}\ mol/L \qquad \leftarrow \textbf{1 mark}$$

$$NiCO_{3(s)} \rightleftarrows Ni^{2+}_{(aq)} + CO^{2}{}_{3}^{-}$$

$$3.79 \times 10^{-4}\,M \qquad 3.79 \times 10^{-4}\,M$$

$$K_{sp} = \left[Ni^{2+}\right]\left[CO_3^{2-}\right]$$

$$= \left(3.79 \times 10^{-4}\right)\left(3.79 \times 10^{-4}\right)$$

$$= 1.4 \times 10^{-7}$$

$\leftarrow$ **2 marks**

(Deduct $\frac{1}{2}$ **mark** for incorrect significant figures.)

7. Define the term *amphiprotic*. Give an example of an ion which is amphiprotic. **(2 marks)**

Solution:

For Example:

The ability to act as either an acid or a base. ← **1 mark**
For example HPO_4^{2-}. ← **1 mark**

8. A $0.0200\,M$ solution of methylamine, CH_3NH_2, has a $pH = 11.40$.
Calculate the K_b for methylamine. **(4 marks)**

Solution:

For Example:

$$pOH = 2.60$$
$$\left[OH^-\right] = 2.51 \times 10^{-3}$$

← **1 mark**

	CH_3NH_2	+ H_2O ⇄	$CH_3NH_3^+$	+ OH^-
[I]	0.0200		0	0
[C]	-2.51×10^{-3}		$+2.51 \times 10^{-3}$	$+2.51 \times 10^{-3}$
[E]	0.01749		2.51×10^{-3}	2.51×10^{-3}

← **1 ½ marks**

$$K_b = \frac{\left[CH_3NH_3^+\right]\left[OH^-\right]}{\left[CH_3NH_2\right]}$$
$$= \frac{\left(2.51 \times 10^{-3}\right)\left(2.51 \times 10^{-3}\right)}{0.01749}$$
$$= 3.6 \times 10^{-4}$$

← **1 ½ marks**

(Deduct **½ mark** for incorrect significant figures.)

9. A titration was performed by adding 0.115 M NaOH to a 25.00 mL sample of H_2SO_4. Calculate the $[H_2SO_4]$ from the following data. **(3 marks)**

	Trial #1	Trial #2	Trial #3
Initial volume of NaOH (mL)	4.00	17.05	8.00
Final volume of NaOH (mL)	17.05	28.00	19.05

Solution:

$$2NaOH + H_2SO_4 \rightleftarrows Na_2SO_4 + 2H_2O$$

vol of NaOH = 11.00 mL ← **1 mark**

mol NaOH = $0.01100\ L(0.115\ mol/L) = 1.265 \times 10^{-3}$ mol ← **½ mark**

mol $H_2SO_4 = \frac{1}{2}(1.265 \times 10^{-3}\ mol\ NaOH) = 6.325 \times 10^{-4}$ mol ← **1 mark**

$$[H_2SO_4] = \frac{6.325 \times 10^{-4}\ mol}{0.02500\ L} = 0.0253\ M$$ ← **½ mark**

10. a) Indicate in the blank spaces on the following chart whether or not a reaction will occur when the metals are added to aqueous ions. **(1 mark)**

ion \ metal	Pd	Rh	Pt
Pd^{2+}		***reaction***	***no reaction***
Rh^{2+}	no reaction		no reaction
Pt^{2+}	reaction	reaction	

Solution:

See table above.

b) List the oxidizing agents in order of strongest to weakest. **(1 mark)**

Solution:

$Pt^{2+} > Pd^{2+} > Rh^{2+}$

11. Balance the following redox reaction in **basic** solution: **(4 marks)**

$$Au + Cl^- + O_2 \rightarrow AuCl_4^- + OH^- \qquad \text{(basic)}$$

Solution:

For Example:

$$4 \times \left(Au + 4Cl^- \rightarrow AuCl_4^- + 3e^-\right)$$
$$3 \times \left(4e^- + 3H^+ + O_2 \rightarrow OH^- + H_2O\right)$$
$$4Au + 16Cl^- + 9H^+ + 3O_2 \rightarrow 4AuCl_4^- + 3OH^- + 3H_2O$$
$$+ 9OH^- \qquad\qquad + 9OH^-$$
$$4Au + 16Cl^- + 6H_2O + 3O_2 \rightarrow 4AuCl_4^- + 12OH^-$$

1 mark for half-reactions

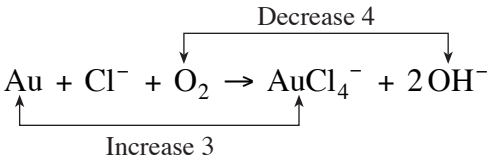
1 mark for balancing charges

1 mark for addition

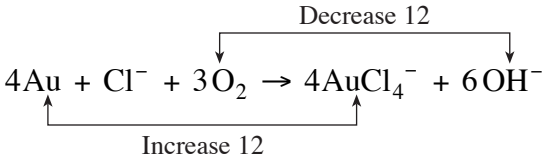
1 mark for basic

OR

For Example:



← **1 mark for oxidation numbers**



← **1 mark for balancing charges**

$$4Au + 16Cl^- + 3O_2 \rightarrow 4AuCl_4^- + 12OH^-$$

← **1 mark for basic charge**

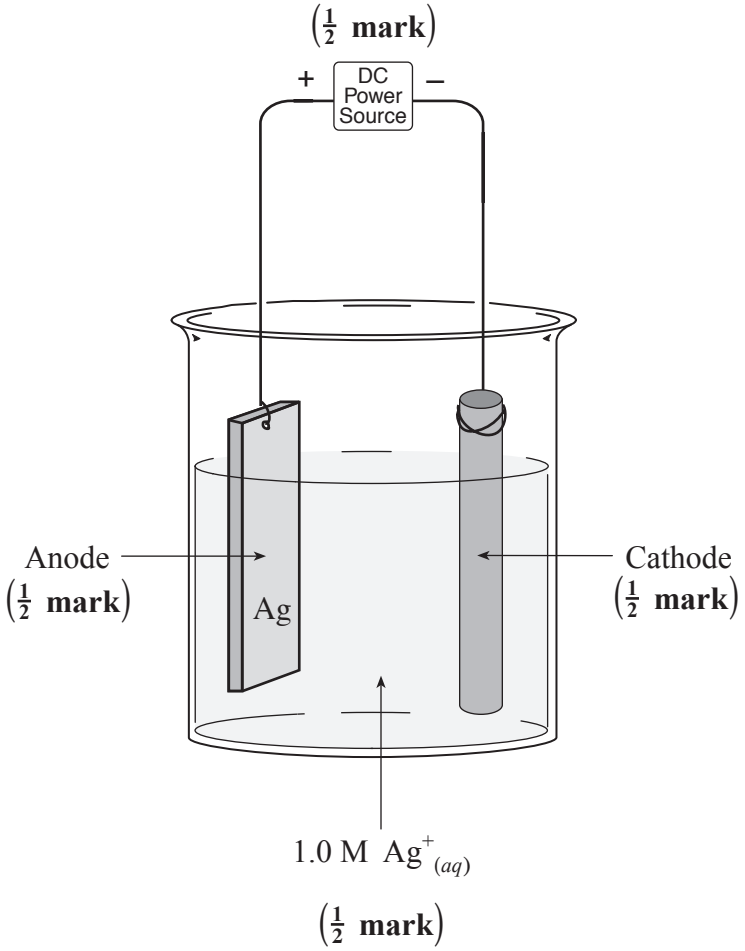
$$4Au + 6H_2O + 16Cl^- + 3O_2 \rightarrow 4AuCl_4^- + 12OH^-$$

← **1 mark for hydrogen (H_2O)**

12. Draw and label a simple electrolytic cell capable of electroplating an inert electrode with silver.
(2 marks)

Solution:

For Example:



END OF KEY