# PROVINCIAL EXAMINATION JUNE ~~JANUARY~~ 2000

**PART A: MULTIPLE CHOICE**

**Value: 48 marks** **Suggested Time: 70 minutes**

1. Which of the following reactions will be slowest at 25°C?

   A. $Cu_{(s)} + S_{(s)} \rightarrow CuS_{(s)}$ B. $H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(\ell)}$ C. $Pb^{2+}_{(aq)} + 2Cl^-_{(aq)} \rightarrow PbCl_{2(s)}$

   D. $2NaOCl_{(aq)} \rightarrow 2NaCl_{(aq)} + O_{2(g)}$

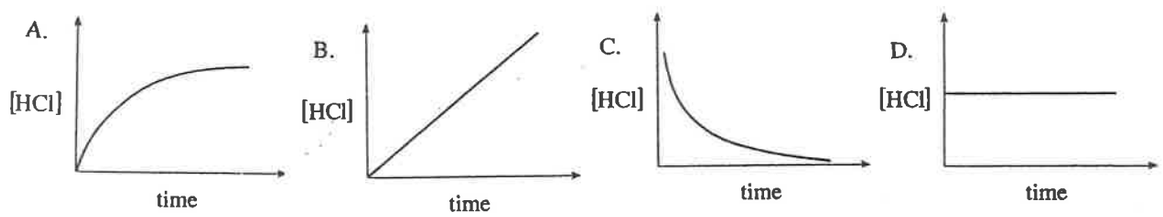
2. Which of the following could be used as the units for rate of a reaction?

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

| | |
|---|---|
| I. | mL/s |
| II. | g/min |
| III. | M/min |

3. Consider the following reaction: $Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$

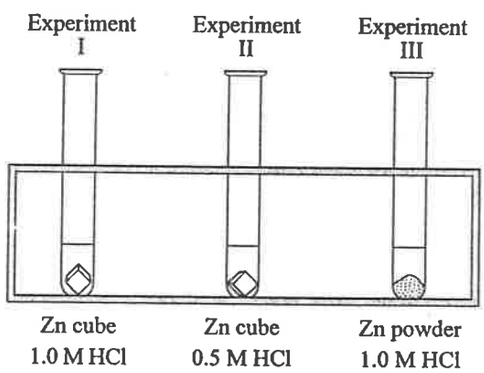
   A graph of concentration of HCl vs time could be represented by




4. Consider the following experiments, each involving equal masses of zinc and 10.0 mL of acid:

   The rate of reaction in order from fastest to slowest is

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




5. What happens to the energy of reactant molecules as they approach one another?

| | Potential Energy | Kinetic Energy |
|---|---|---|
| A. | increases | increases |
| B. | increases | decreases |
| C. | decreases | increases |
| D. | decreases | decreases |

6. Consider the following reaction mechanism:

| | |
|---|---|
| Step 1 | $ClO^- + H_2O \rightarrow HClO + OH^-$ |
| Step 2 | $I^- + HClO \rightarrow HIO + Cl^-$ |
| Step 3 | $HIO + OH^- \rightarrow IO^- + H_2O$ |

   The catalyst is

   A. $IO^-$ C. $ClO^-$
   B. $H_2O$ D. ClOH

7. Consider the following equilibrium: $2NOCl_{(g)} \rightleftarrows 2NO_{(g)} + Cl_{2(g)}$

   A flask of fixed volume is initially filled with $NOCl_{(g)}$, $NO_{(g)}$ and $Cl_{2(g)}$. When equilibrium is reached, the pressure has increased. To reach equilibrium, the reaction proceeded to the

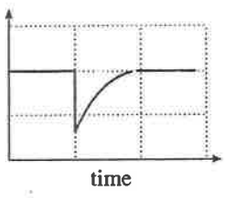
   A. left because Trial $K_{eq}$ was less than $K_{eq}$.
   B. right because Trial $K_{eq}$ was less than $K_{eq}$.
   C. left because Trial $K_{eq}$ was greater than $K_{eq}$.
   D. right because Trial $K_{eq}$ was greater than $K_{eq}$.

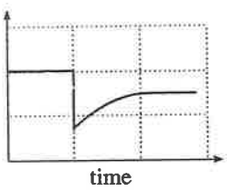
8. In which of the following do both minimum enthalpy and maximum entropy factors favour the reactants?

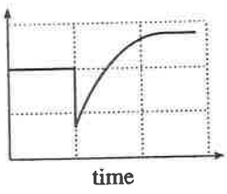
   A. $Cl_{2(g)} \rightleftarrows Cl_{2(aq)}$ $\Delta H = -25\,kJ$
   B. $C_{(s)} + H_2O_{(\ell)} \rightleftarrows CO_{(g)} + H_{2(g)}$ $\Delta H = +131\,kJ$
   C. $2CO_{2(g)} + 3H_2O_{(\ell)} \rightleftarrows C_2H_5OH_{(\ell)} + 3O_{2(g)}$ $\Delta H = +1239\,kJ$
   D. $Na_2CO_{3(s)} + HCl_{(aq)} \rightleftarrows 2NaCl_{(aq)} + CO_{2(g)} + H_2O_{(\ell)}$ $\Delta H = -28\,kJ$

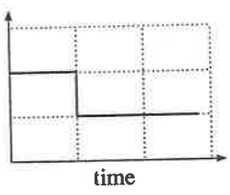
9. Consider the following equilibrium: $H_{2(g)} + I_{2(g)} \rightleftarrows 2HI_{(g)}$

Which graph represents what happens when some HI is removed and a new equilibrium is established?

A. 


B. 


C. 


D. 


10. Consider the following equilibrium: $CO_{(g)} + H_2O_{(g)} \rightleftarrows CO_{2(g)} + H_{2(g)}$ $\Delta H = -41\,kJ$

What will cause a shift in the equilibrium?

A. adding a catalyst B. changing volume C. adding an inert gas D. changing temperature

11. The equilibrium expression for a reaction is $K_{eq} = \dfrac{[H^+]^6}{[Bi^{3+}]^2[H_2S]^3}$

The reaction could be

A. $6H^+_{(aq)} + BiS_{(s)} \rightleftarrows 2Bi^{3+}_{(aq)} + 3H_2S_{(g)}$

B. $6H^+_{(aq)} + Bi_2S_{3(s)} \rightleftarrows 2Bi^{3+}_{(aq)} + 3H_2S_{(g)}$

C. $2Bi^{3+}_{(aq)} + 3H_2S_{(aq)} \rightleftarrows Bi_2S_{3(s)} + 6H^+_{(aq)}$

D. $2Bi^{3+}_{(aq)} + 3H_2S_{(aq)} \rightleftarrows Bi_2S_{3(aq)} + 6H^+_{(aq)}$

12. Consider the following equilibrium: $Co(H_2O)_{6\,(aq)}^{2+} + 4Cl^-_{(aq)} \rightleftarrows CoCl_{4\,(aq)}^{2-} + 6H_2O_{(\ell)}$

(pink) (blue)

When the temperature is increased, the solution turns a dark blue. Based on this observation, the reaction is

A. exothermic and the $K_{eq}$ has increased.
B. exothermic and the $K_{eq}$ has decreased.
C. endothermic and the $K_{eq}$ has increased.
D. endothermic and the $K_{eq}$ has decreased.

13. Consider the following equilibrium: $2O_{3(g)} \rightleftarrows 3O_{2(g)}$ $K_{eq} = 36$

What is the concentration of $O_3$ when the equilibrium concentration of $O_2$ is $6.0 \times 10^{-2}$ mol/L?

A. $2.4 \times 10^{-3}$ mol/L B. $4.0 \times 10^{-2}$ mol/L C. $6.0 \times 10^{-2}$ mol/L D. $9.0 \times 10^{-2}$ mol/L

14. A saturated solution of NaCl contains 36.5 g of solute in 0.100 L of solution. The solubility of the compound is

A. 0.062 M B. 1.60 M C. 3.65 M D. 6.24 M

15. Calculate the $[Li^+]$ in 200.0 mL of 1.5 M $Li_2SO_4$.

A. 0.30 M B. 0.60 M C. 1.5 M D. 3.0 M

16. When equal volumes of 0.20 M RbCl and 0.20 M SrS are combined,

A. no precipitate forms.
B. a precipitate of $Rb_2S$ only forms.
C. a precipitate of $SrCl_2$ only forms.
D. precipitates of both $Rb_2S$ and $SrCl_2$ form.

17. A solution contains both $Ag^+$ and $Mg^{2+}$ ions. During selective precipitation, these ions are removed one at a time by adding

A. $I^-$ followed by $OH^-$ B. $OH^-$ followed by $S^{2-}$ C. $SO_4^{2-}$ followed by $Cl^-$ D. $NO_3^-$ followed by $PO_4^{3-}$

18. The $K_{sp}$ expression for a saturated solution of $Mg(OH)_2$ is

A. $K_{sp} = \dfrac{[Mg^{2+}][OH^-]^2}{[Mg(OH)_2]}$ B. $K_{sp} = [Mg^{2+}][OH^-]^2$ C. $K_{sp} = [Mg^{2+}][OH^-]$ D. $K_{sp} = [Mg^{2+}][2\,OH^-]^2$

19. Consider the following saturated solutions: $CuSO_4$, $BaSO_4$, $CaSO_4$ The order of cation concentration, from highest to lowest, is

A. $[Ba^{2+}] > [Ca^{2+}] > [Cu^{2+}]$ B. $[Ca^{2+}] > [Cu^{2+}] > [Ba^{2+}]$ C. $[Cu^{2+}] > [Ca^{2+}] > [Ba^{2+}]$ D. $[Cu^{2+}] > [Ba^{2+}] > [Ca^{2+}]$

20. When $1.0 \times 10^{-3}$ moles of $CuCl_{2(s)}$ are added to 1.0 L of $1.0 \times 10^{-3}$ M $IO_3^-$, the

A. Trial $K_{sp} > K_{sp}$ and a precipitate forms.
B. Trial $K_{sp} < K_{sp}$ and a precipitate forms.
C. Trial $K_{sp} > K_{sp}$ and no precipitate forms.
D. Trial $K_{sp} < K_{sp}$ and no precipitate forms.

21. The conjugate base of $H_2PO_4^-$ is

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

22. Aqua regia is a concentrated aqueous solution of HCl and $HNO_3$. The strongest acid in aqua regia is

A. HCl B. $H_2O$ C. $H_3O^+$ D. $HNO_3$

23. The predominant acid-base reaction between $H_2O_2$ and $H_2O$ is

A. $H_2O_2 + H_2O \rightarrow 3OH^- + H^+$
B. $H_2O_2 + H_2O \rightarrow 2H_2O + O^{2-}$
C. $H_2O_2 + H_2O \rightarrow H_3O_2^+ + OH^-$
D. $H_2O_2 + H_2O \rightarrow H_3O^+ + HO_2^-$

24. Which of the following reactions favours the formation of products?

A. $HNO_2 + F^- \rightleftarrows HF + NO_2^-$
B. $H_2CO_3 + IO_3^- \rightleftarrows HIO_3 + HCO_3^-$
C. $NH_4^+ + C_2O_4^{2-} \rightleftarrows HC_2O_4^- + NH_3$
D. $HCN + HCOO^- \rightleftarrows HCOOH + CN^-$

25. Which of the following 1.0 M solutions will have the lowest $[H_3O^+]$ ?

A. $H_2S$ B. $HNO_2$ C. $H_2CO_3$ D. $CH_3COOH$

26. In a solution of 0.10 M NaCN, the order of ion concentration, from highest to lowest, is

A. $[Na^+] > [OH^-] > [CN^-] > [H_3O^+]$
B. $[Na^+] > [CN^-] > [OH^-] > [H_3O^+]$
C. $[H_3O^+] > [OH^-] > [CN^-] > [Na^+]$
D. $[OH^-] > [Na^+] > [CN^-] > [H_3O^+]$

27. What will cause the value of $K_w$ to change?

A. adding $OH^-$ B. adding a catalyst C. decreasing the pH D. increasing the temperature

28. What is the concentration of $Sr(OH)_2$ in a solution with a pH = 11.00?

A. $2.0 \times 10^{-11}$ M B. $1.0 \times 10^{-11}$ M C. $5.0 \times 10^{-4}$ M D. $1.0 \times 10^{-3}$ M

29. The $K_a$ expression for $HTe^-$ is

A. $K_a = \dfrac{[H_2Te][OH^-]}{[HTe^-]}$ B. $K_a = \dfrac{[Te^{2-}][H_3O^+]}{[HTe^-]}$ C. $K_a = \dfrac{[HTe^-][H_3O^+]}{[H_2Te]}$ D. $K_a = \dfrac{[HTe^-][OH^-]}{[Te^{2-}]}$

30. When comparing 1.0 M solutions of bases, the base with the lowest $[OH^-]$ is the

A. weakest base and it has the largest $K_b$ value.
B. strongest base and it has the largest $K_b$ value.
C. weakest base and it has the smallest $K_b$ value.
D. strongest base and it has the smallest $K_b$ value.

31. The value of $K_b$ for $HC_2O_4^-$ is

A. $1.7 \times 10^{-13}$ B. $1.6 \times 10^{-10}$ C. $6.4 \times 10^{-5}$ D. $5.9 \times 10^{-2}$

32. Which of the following applies at the transition point for all indicators, HInd?

A. $[HInd] = [Ind^-]$ B. $[Ind^-] = [H_3O^+]$ C. $[H_3O^+] = [OH^-]$ D. $[HInd] = [H_3O^+]$

33. Identify the indicator that has a $K_a$ of $1.6 \times 10^{-7}$ ?

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

34. Which of the following acid solutions would require the smallest volume to completely neutralize 10.00 mL of 0.100 M NaOH ?

A. 0.100 M HCl B. 0.100 M $H_3PO_4$ C. 0.100 M $H_2C_2O_4$ D. 0.100 M $CH_3COOH$

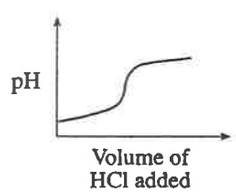
35. What is the pH of the solution formed when 0.040 mol $NaOH_{(s)}$ is added to 1.00 L of 0.050 M HCl ?

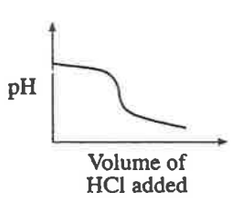
A. 1.30 B. 1.40 C. 2.00 D. 7.00

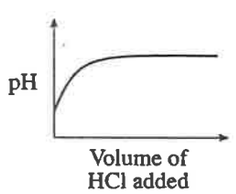
36. Which of the following titrations will have an equivalence point with a pH less than 7.00?

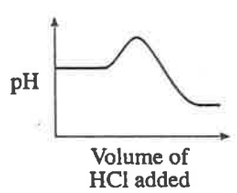
A. $H_2SO_4$ with $NH_3$ B. $HNO_3$ with LiOH C. $H_3PO_4$ with KOH D. HCOOH with NaOH

37. Which of the following graphs describes the relationship between pH of a buffer solution and a volume of HCl added to the buffer?

A.



B.



C.



D.



38. A substance that is reduced during a redox reaction

A. loses mass. B. is the anode. C. is the reducing agent. D. is the oxidizing agent.

39. The oxidation number of As in $H_4As_2O_7$ is

A. +4 B. +5 C. +9 D. +10

40. In a reaction, the oxidation number of Cr decreases by 3. This indicates that Cr is

A. reduced. B. oxidized. C. neutralized. D. a reducing agent.

41. Consider the following redox reaction: $C_2H_5OH + 2Cr_2O_7^{2-} + 16H^+ \rightarrow 2CO_2 + 4Cr^{3+} + 11H_2O$

Each carbon atom loses

A. 2 electrons B. 4 electrons C. 6 electrons D. 12 electrons

42. In which of the following 1.0 M solutions will both ions react spontaneously with tin?

A. $Ag^+$ and $Cu^{2+}$ B. $Ni^{2+}$ and $Cu^{2+}$ C. $Zn^{2+}$ and $Ni^{2+}$ D. $Mg^{2+}$ and $Zn^{2+}$

43. Consider the following half-reaction: $Bi_2O_4 \rightarrow BiO^+$ (acidic) The balanced equation for this half-reaction is

A. $Bi_2O_4 + 6H^+ + 5e^- \rightarrow BiO^+ + 3H_2O$
B. $Bi_2O_4 + 8H^+ + 6e^- \rightarrow 2BiO^+ + 4H_2O$
C. $Bi_2O_4 + 4H^+ + 2e^- \rightarrow 2BiO^+ + 2H_2O$
D. $Bi_2O_4 + 4H^+ + 3e^- \rightarrow 2BiO^+ + 2H_2O$

44. To determine the concentration of $Fe^{2+}_{(aq)}$ by a redox titration, we could use an acidified standard solution of

A. $Sn^{2+}$ B. $Pb^{2+}$ C. HCl D. $H_2O_2$

45. Consider the following redox reactions:

$2Ag^+ + Cd \rightarrow 2Ag + Cd^{2+}$ $E° = 1.20\,V$

$3Cd^{2+} + 2Nb \rightarrow 2Nb^{3+} + 3Cd$ $E° = 0.70\,V$

What is the E° for $Nb^{3+} + 3e^- \rightarrow Nb$?

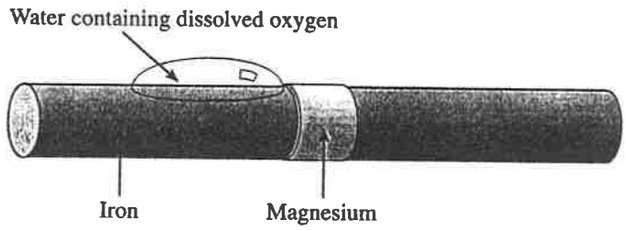
A. −1.90 V B. −1.10 V C. −0.50 V D. −0.40 V

46. Consider the overall reaction for the rechargeable nickel-cadmium battery: $Cd + NiO_2 + 2H_2O \rightarrow Cd(OH)_2 + Ni(OH)_2$

Which of the following occurs at the cathode as the reaction proceeds?

A. Cd loses $2e^-$ and $Cd(OH)_2$ forms
B. Cd gains $2e^-$ and $Cd(OH)_2$ forms
C. $NiO_2$ loses $2e^-$ and $Ni(OH)_2$ forms
D. $NiO_2$ gains $2e^-$ and $Ni(OH)_2$ forms

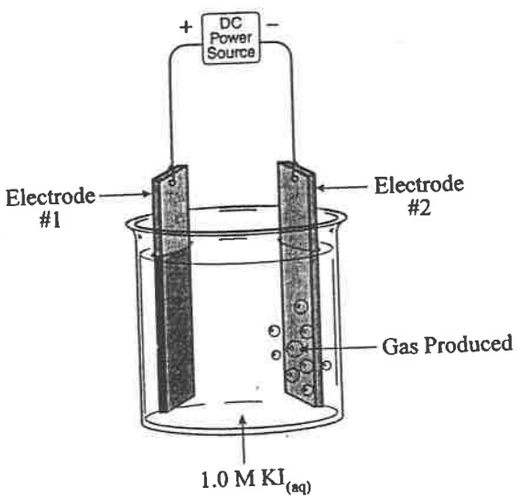
47. Consider the following diagram of a piece of iron, cathodically protected by magnesium:




What is happening during this process?

A. Iron acts as the anode and water is oxidized.
B. Iron acts as the cathode and oxygen is reduced.
C. Magnesium acts as the anode and iron is oxidized.
D. Magnesium acts as the cathode and iron is reduced.

48. Consider the following operating cell:




Which of the following describes the cell above?

| | Electrode #1 | Electrode #2 | Gas Produced |
|---|---|---|---|
| A. | anode | cathode | $H_{2(g)}$ |
| B. | anode | cathode | $O_{2(g)}$ |
| C. | cathode | anode | $H_{2(g)}$ |
| D. | cathode | anode | $O_{2(g)}$ |

## PART B: WRITTEN RESPONSE

**Value: 32 marks** **Suggested Time: 50 minutes**

1. a) Complete the steps in the following mechanism.

**(1½ marks)**

| | |
|---|---|
| Step 1 | $NO + Pt \rightarrow$ _____ |
| Step 2 | $NOPt + NO \rightarrow$ _____ + _____ |
| Step 3 | $O_2Pt \rightarrow O_2 + Pt$ |
| Overall | $2NO \rightarrow N_2 + O_2$ |

b) Define the term *reaction intermediate* and give an example from the completed mechanism above.

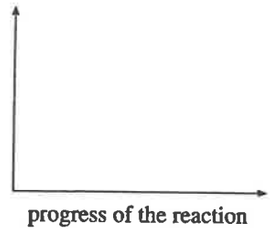
**(1½ marks)**

2. Consider the observations for the following equilibrium: $N_2O_{4(g)} \rightleftarrows 2NO_{2(g)}$

(colourless) (brown)

| Trial | Temperature °C | Colour |
|---|---|---|
| I. | 10 | light brown |
| II. | 50 | dark brown |

a) Sketch the potential energy curve on the graph below for this equilibrium. **(1 mark)**




b) Explain the colour change using Le Châtelier's Principle. **(1 mark)**

c) Other than changing temperature, what could be done to cause a shift to the left? **(1 mark)**

3. Consider the data obtained for the following equilibrium:

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

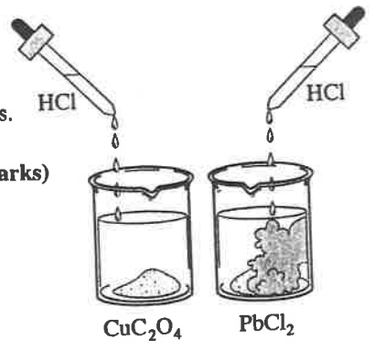
Calculate the $[FeSCN^{2+}]$ in experiment #2. **(3 marks)**

| | $[Fe^{3+}]$ | $[SCN^-]$ | $[FeSCN^{2+}]$ |
|---|---|---|---|
| Experiment 1 | $3.91 \times 10^{-2}$ | $8.02 \times 10^{-5}$ | $9.22 \times 10^{-4}$ |
| Experiment 2 | $6.27 \times 10^{-3}$ | $3.65 \times 10^{-4}$ | ? |

4. At 25°C, will a precipitate form when 25.0 mL of 0.010 M $Pb(NO_3)_2$ is combined with 75.0 mL of 0.010 M NaI? Support your answer with calculations. **(3 marks)**

5. When HCl is added to a saturated solution of $CuC_2O_4$, some precipitate dissolves. However, when HCl is added to a saturated solution of $PbCl_2$, additional precipitate forms.

Explain these observations. Support your explanation with chemical equations. **(3 marks)**




6. A 0.100 M solution of an unknown weak acid, HX, has a pH = 1.414. What is the $K_a$ for HX? **(4 marks)**

7. Consider the salt ammonium acetate, $NH_4CH_3COO$.

a) Write the equation for the dissociation of $NH_4CH_3COO$. **(1 mark)**

b) Write equations for the hydrolysis reactions which occur. **(2 marks)**

c) Explain why a solution of $NH_4CH_3COO$ has a pH = 7.00. Support your answer with calculations. **(2 marks)**

8. The metals Rh, Ti, Cr and Pd are individually placed in 1.0 M solutions of $Rh^{2+}$, $Ti^{2+}$, $Cr^{2+}$ and $Pd^{2+}$ and the cell voltages of the spontaneous reactions are determined.

| METAL \ ION | $Rh^{2+}$ | $Ti^{2+}$ | $Pd^{2+}$ | $Cr^{2+}$ |
|---|---|---|---|---|
| Rh | | no reaction | 0.35 V | no reaction |
| Ti | 2.23 V | | 2.58 V | ? |
| Pd | no reaction | no reaction | | no reaction |
| Cr | 1.51 V | no reaction | 1.86 V | |

a) Arrange the metals in order of **increasing** strength as reducing agents. **(2 marks)**

weakest reducing agent _____, _____, _____, _____ strongest reducing agent

b) Determine the cell voltage for Ti in a 1.0 M solution of $Cr^{2+}$. **(2 marks)**

9. Consider the following reactions for a fuel cell :

cathode: $O_{2(g)} + 2H_2O_{(\ell)} + 4e^- \rightarrow 4OH^-_{(aq)}$

anode: ?

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

a) Write the reaction at the anode. **(1 mark)**

b) Discuss the advantage of a fuel-cell powered vehicle over an internal combustion powered vehicle by comparing the products formed. **(1 mark)**

10. Draw and label an electrochemical cell using a copper anode and having an E° value > 1.00 V. **(2 marks)**

## ANSWER KEY / SCORING GUIDE **Part A: Multiple Choice**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1. | A | 11. | C | 21. | D | 31. | A | 41. | C |
| 2. | D | 12. | C | 22. | C | 32. | A | 42. | A |
| 3. | C | 13. | A | 23. | D | 33. | D | 43. | C |
| 4. | C | 14. | D | 24. | A | 34. | B | 44. | D |
| 5. | B | 15. | D | 25. | A | 35. | C | 45. | B |
| 6. | B | 16. | A | 26. | B | 36. | A | 46. | D |
| 7. | B | 17. | A | 27. | D | 37. | B | 47. | B |
| 8. | C | 18. | B | 28. | C | 38. | D | 48. | A |
| 9. | B | 19. | C | 29. | B | 39. | B | | |
| 10. | D | 20. | D | 30. | C | 40. | A | | |

**PART B: WRITTEN RESPONSE**

1. a) **Solution:**

*For Example:*

| | | |
|---|---|---|
| Step 1 | $NO + Pt \rightarrow \underline{NOPt}$ | ← ½ mark |
| Step 2 | $NOPt + NO \rightarrow \underline{N_2} + \underline{O_2Pt}$ | ← 1 mark |

b) **Solution:** *For Example:*

Definition: A substance which forms in one step of a mechanism and is used up in a later step. ← 1 mark

Example: NOPt or $O_2Pt$ ← ½ mark

2. a) **Solution:**


← 1 mark

b) **Solution:** *For Example:*

An increase in temperature causes the reaction to shift to the right and the $[NO_2]$ increases. ← 1 mark

c) **Solution:** *For Example:* To cause a shift to the left add $NO_2$ or remove $N_2O_4$ or decrease the volume. ← 1 mark

3. **Solution:** $K_{eq} = \dfrac{[FeSCN^{2+}]}{[Fe^{3+}][SCN^-]} = \dfrac{9.22 \times 10^{-4}}{(3.91 \times 10^{-2})(8.02 \times 10^{-5})} = 2.94 \times 10^2$ ← 1½ mark

$2.94 \times 10^2 = \dfrac{x}{(6.27 \times 10^{-3})(3.65 \times 10^{-4})}$ $[FeSCN^{2+}] = x = 6.73 \times 10^{-4}\,M$ ← 1½ mark

4. **Solution:** *For Example:* $PbI_{2(s)} \rightleftarrows Pb^{2+}_{(aq)} + 2I^-_{(aq)}$

$[Pb^{2+}] = 0.010\,M \times \dfrac{25.0\,mL}{100.0\,mL} = 0.00250\,M$ $[I^-] = 0.010\,M \times \dfrac{75.0\,mL}{100.0\,mL} = 0.00750\,M$ ← 1 mark

Trial $K_{sp} = [Pb^{2+}][I^-]^2 = (0.00250)(0.00750)^2 = 1.4 \times 10^{-7}$ ← 1½ mark

Since Trial $K_{sp}\,(1.4 \times 10^{-7}) > K_{sp}(8.5 \times 10^{-9})$ a precipitate does form. } ← ½ mark

5. **Solution:** *For Example:* $CuC_2O_{4(s)} \rightleftarrows Cu^{2+}_{(aq)} + C_2O_4^{2-}{}_{(aq)}$ ← ½ mark

$H^+$ from the acid reacts with the $C_2O_4^{2-}$ to form $HC_2O_4^-$ reducing the $[C_2O_4^-]$ and causing a shift to the product side. 1 mark

$Pb^{2+}_{(aq)} + 2Cl^-_{(aq)} \rightleftarrows PbCl_{2(s)}$ ← ½ mark The common ion effect causes a shift to the right. ← 1 mark

6. **Solution:** *For Example:* $[H_3O^+] = 0.03855\,M$ ← 1 mark

$K_a = \dfrac{[H_3O^+][X^-]}{[HX]}$

$K_a = \dfrac{(0.03855)(0.03855)}{0.061}$

$= 0.024$

} ← 1½ marks

| | HX | + $H_2O$ ⇄ | $H_3O^+$ | + $X^-$ |
|---|---|---|---|---|
| [I] | 0.100 | | 0 | 0 |
| [C] | −0.03855 | | +0.03855 | +0.03855 |
| [E] | 0.061 | | 0.03855 | 0.03855 |

} ← 1½ marks

7. a) **Solution:** $NH_4CH_3COO_{(s)} \rightarrow NH_4^+{}_{(aq)} + CH_3COO^-_{(aq)}$ ← 1 mark

b) **Solution:** $NH_4^+ + H_2O \rightleftarrows H_3O^- + NH_3$ and $CH_3COO^- + H_2O \rightleftarrows CH_3COOH + OH^-$ ← 2 marks

c) **Solution:** $K_a$ for $NH_4^+ = 5.6 \times 10^{-10}$

$K_b$ for $CH_3COO^- = \dfrac{1.0 \times 10^{-14}}{1.8 \times 10^{-5}} = 5.6 \times 10^{-10}$ 2 marks

the $K_a$ for $NH_4^+ = K_b$ for $CH_3COO^-$ ∴ the acidic cation is completely neutralized by the basic anion.

8. a) **Solution:** 2 marks

weakest reducing agent ___Pd___, ___Rh___, ___Cr___, ___Ti___ strongest reducing agent

b) **Solution:** *For Example:* $Ti + Rh^{2+} = 2.23\,V$ $Cr + Rh^{2+} = 1.51\,V$

Cell voltage of $Ti + Cr^{2+} = 2.23\,V - 1.51\,V = 0.72\,V$ ← 2 marks

9. a) **Solution:** *For Example:*

$2H_{2(g)} + 4OH^-_{(aq)} \rightarrow 4H_2O_{(\ell)} + 4e^-$ ← 1 mark

b) **Solution:** *For Example:*

The $NO_x$ produced by internal combustion cars is a source of acid rain. The $H_2O$ from a fuel-cell car is non-polluting. } ← 1 mark

10. ½ mark for suitable cathode — Au for example.

½ mark for suitable ions — $Au^{3+}$ and $Cu^{2+}$ for example.

**Solution:** 1 mark for diagram being an electrochemical cell, not an electrolytic cell.

*For Example:*