BRITISH COLUMBIA

Chemistry 12

JUNE 2002

Course Code = CH

Student Instructions

1. Place the stickers with your Personal Education Number (PEN) in the allotted spaces above. **Under no circumstance is your name or identification, other than your Personal Education Number, to appear on this booklet.**

2. Ensure that in addition to this examination booklet, you have a **Data Booklet** and an **Examination Response Form**. Follow the directions on the front of the Response Form.

3. **Disqualification** from the examination will result if you bring books, paper, notes or unauthorized electronic devices into the examination room.

4. 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 Response Form inside the front cover of this booklet and return the booklet and your Response Form to the supervisor.

Value: 60 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.
	Selected multiple-choice questions are worth 2 marks.

1. Which of the following has the lowest rate of reaction?   **(1 mark)**

    A. $Pb_{(s)} + CuCl_{2(aq)} \rightarrow Cu_{(s)} + PbCl_{2(aq)}$

    B. $HCl_{(aq)} + NaOH_{(aq)} \rightarrow H_2O_{(\ell)} + NaCl_{(aq)}$

    C. $H_2SO_{4(aq)} + Ba(OH)_{2(aq)} \rightarrow 2H_2O_{(\ell)} + BaSO_{4(s)}$

    D. $Pb(NO_3)_{2(aq)} + 2NaI_{(aq)} \rightarrow PbI_{2(s)} + 2NaNO_{3(aq)}$

2. Which of the following affects the rate of heterogeneous reactions, but does not affect the rate of homogeneous reactions?   **(1 mark)**

    A.   catalyst
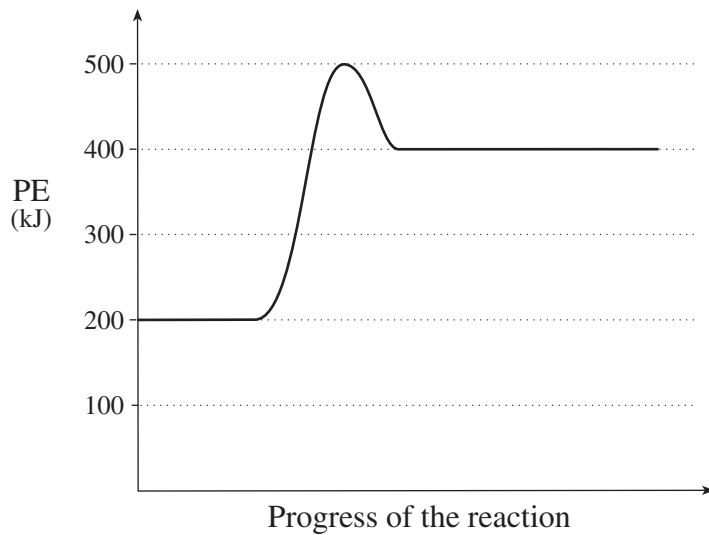   B.   temperature
    C.   surface area
    D.   concentration

3. As reactant particles approach each other, what changes occur in KE and PE?   **(1 mark)**

	KE	PE
A.	increases	increases
B.	increases	decreases
C.	decreases	increases
D.	decreases	decreases

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4. Consider the following PE diagram: **(1 mark)**

What is the minimum potential energy required to change reactants to the activated complex?

A. 200 kJ
B. 300 kJ
C. 400 kJ
D. 500 kJ
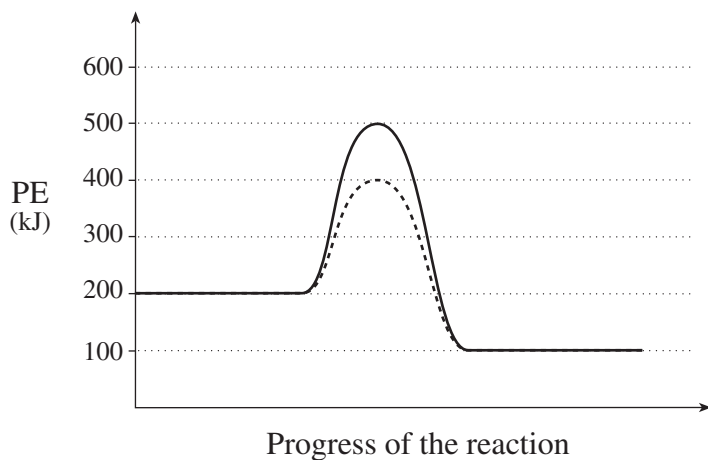
5. Consider the following reaction mechanism: **(1 mark)**

Step 1	$2NO_2 \rightarrow NO_3 + NO$
Step 2	$NO_3 + CO \rightarrow NO_2 + CO_2$

Identify a product in the overall reaction.

A. CO
B. CO_2
C. NO_2
D. NO_3

6. Consider the following PE diagram for a catalyzed and uncatalyzed reaction: **(2 marks)**
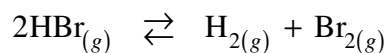

Progress of the reaction

Which of the following describes the **reverse** reaction?

	Reverse Reaction	Activation Energy (kJ)	ΔH (kJ)
A.	uncatalyzed	300	−100
B.	catalyzed	300	−100
C.	uncatalyzed	400	+100
D.	catalyzed	400	+100

7. Consider the following: **(1 mark)**
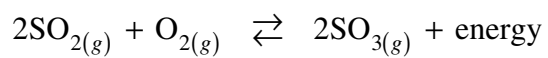
$$2HBr_{(g)} \rightleftarrows H_{2(g)} + Br_{2(g)}$$

Initially, HBr is added to an empty flask. How do the rate of the forward reaction and the [HBr] change as the system proceeds to equilibrium?

	Forward Rate	[HBr]
A.	decreases	decreases
B.	decreases	increases
C.	increases	increases
D.	increases	decreases

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Use the following equilibrium equation to answer questions 8 and 9.

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

8. Which of the following two stresses will each cause the system to shift to the right? **(1 mark)**
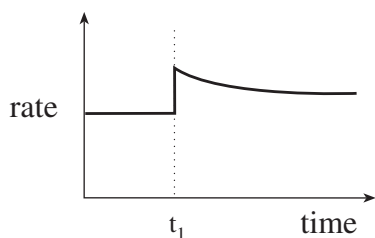
 A. decrease temperature, decrease $[O_2]$

 B. increase temperature, increase $[SO_3]$

 C. increase temperature, decrease $[SO_3]$

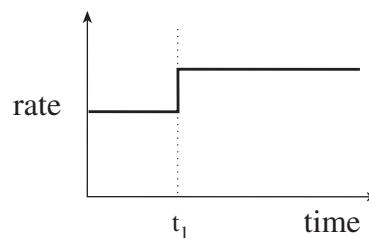 D. decrease temperature, increase $[SO_2]$

9. Which of the following graphs shows the **reverse** rate of reaction when a catalyst is added to the equilibrium at time $= t_1$? **(1 mark)**
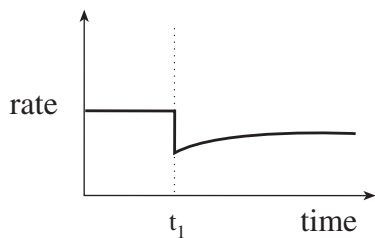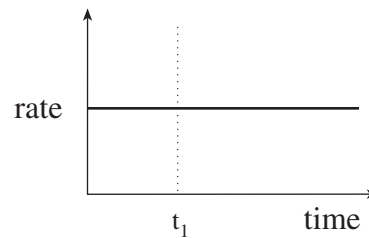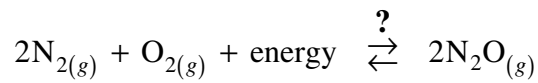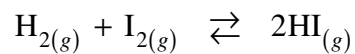
A.

B.

C.

D.

10. Consider the following: **(2 marks)**

$$2N_{2(g)} + O_{2(g)} + \text{energy} \overset{?}{\rightleftarrows} 2N_2O_{(g)}$$

What positions do minimum enthalpy and maximum entropy tend toward?

	Minimum Enthalpy	Maximum Entropy
A.	products	products
B.	products	reactants
C.	reactants	products
D.	reactants	reactants

11. Consider the following: **(1 mark)**
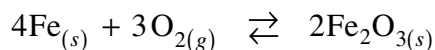
$$H_{2(g)} + I_{2(g)} \rightleftarrows 2HI_{(g)}$$

Initially, some HI is placed into a 1.0 L container. At equilibrium there is 0.010 mol H_2, 0.010 mol I_2 and 0.070 mol HI present. How many moles of HI were initially added to the container?

A. 0.060 mol
B. 0.070 mol
C. 0.080 mol
D. 0.090 mol

12. What is the equilibrium expression for the following system? **(1 mark)**

$$4Fe_{(s)} + 3O_{2(g)} \rightleftarrows 2Fe_2O_{3(s)}$$

A. $K_{eq} = [O_2]^3$

B. $K_{eq} = \dfrac{1}{[O_2]^3}$

C. $K_{eq} = \dfrac{[Fe_2O_3]^2}{[Fe]^4[O_2]^3}$

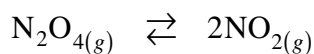D. $K_{eq} = \dfrac{[2Fe_2O_3]}{[4Fe][3O_2]}$

13. What will cause the value of K_{eq} for an endothermic reaction to increase? **(1 mark)**

   A. increasing [products]
   B. decreasing [products]
   C. increasing the temperature
   D. decreasing the temperature

14. Consider the following equilibrium: **(2 marks)**

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

An equilibrium mixture contains 4.0×10^{-2} mol N_2O_4 and 1.5×10^{-2} mol NO_2 in a $1.0\,L$ flask. What is the value of K_{eq} ?

   A. 5.6×10^{-3}
   B. 3.8×10^{-1}
   C. 7.5×10^{-1}
   D. 1.8×10^2

15. In every solubility equilibrium, the rate of dissolving is **(1 mark)**

    A. equal to zero.
    B. equal to the rate of crystallization.
    C. less than the rate of crystallization.
    D. greater than the rate of crystallization.

16. A $3.0\,L$ solution of $BaCl_2$ has a chloride ion concentration of $0.20\,M$.
The barium ion concentration in this solution is **(1 mark)**

    A. 0.067 M
    B. 0.10 M
    C. 0.20 M
    D. 0.60 M

17. Which of the following has the lowest solubility? **(2 marks)**

    A. CaS
    B. CuS
    C. FeS
    D. MgS

18. What is the formula equation for the reaction that occurs when equal volumes
of $0.20\,M\ K_3PO_4$ and $0.20\,M\ ZnCl_2$ are mixed together? **(1 mark)**

    A. $K^+_{(aq)} + Cl^-_{(aq)} \rightarrow KCl_{(s)}$

    B. $3Zn^{2+}_{(aq)} + 2PO_4^{3-}_{(aq)} \rightarrow Zn_3(PO_4)_{2(s)}$

    C. $2K_3PO_{4(aq)} + 3ZnCl_{2(aq)} \rightarrow Zn_3(PO_4)_{2(s)} + 6KCl_{(aq)}$

    D. $2K_3PO_{4(aq)} + 3\,ZnCl_{2(aq)} \rightarrow 3Zn_3(PO_4)_{2(aq)} + 6KCl_{(s)}$

19. Which of the following could be added to a sample of hard water to remove both $0.2\,M\ Ca^{2+}$ and $0.2\,M\ Mg^{2+}$? **(1 mark)**

    A. $0.2\,M\ S^{2-}$
    B. $0.2\,M\ Cl^{-}$
    C. $0.2\,M\ OH^{-}$
    D. $0.2\,M\ SO_4^{2-}$

20. The K_{sp} expression for a saturated solution of Ag_2SO_3 is **(1 mark)**

    A. $K_{sp} = \left[2Ag^{+}\right]\left[SO_3^{2-}\right]$
    B. $K_{sp} = \left[Ag^{+}\right]^2\left[SO_3^{2-}\right]$
    C. $K_{sp} = \left[Ag_2^{2+}\right]\left[SO_3^{2-}\right]$
    D. $K_{sp} = \left[2Ag^{+}\right]^2\left[SO_3^{2-}\right]$

21. The solubility of CaF_2 is $3.3 \times 10^{-4}\ M$. Determine the K_{sp} value of CaF_2 . **(2 marks)**

    A. 3.6×10^{-11}
    B. 1.4×10^{-10}
    C. 1.1×10^{-7}
    D. 3.3×10^{-4}

22. What is the maximum $\left[Ag^{+}\right]$ that can exist in a solution of $0.010\,M\ NaIO_3$? **(1 mark)**

    A. $3.2 \times 10^{-10}\ M$
    B. $3.2 \times 10^{-8}\ M$
    C. $3.2 \times 10^{-6}\ M$
    D. $1.8 \times 10^{-4}\ M$

23. An *Arrhenius base* is defined as a substance that **(1 mark)**

    A. releases $H^+_{(aq)}$

    B. releases $OH^-_{(aq)}$

    C. accepts a proton

    D. donates a proton

24. The conjugate acid of $HAsO_4^{2-}$ is **(1 mark)**
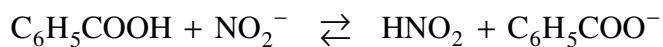
    A. AsO_4^{3-}

    B. AsO_4^{2-}

    C. $H_2AsO_4^-$

    D. $H_2AsO_4^{2-}$

25. Which of the following will have the greatest electrical conductivity? **(1 mark)**

    A. $1.0\,M$ HF

    B. $1.0\,M$ HBr

    C. $1.0\,M$ HCN

    D. $1.0\,M$ H_2SO_3

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26. Consider the equilibrium: **(2 marks)**

$$C_6H_5COOH + NO_2^- \rightleftarrows HNO_2 + C_6H_5COO^-$$

Identify the stronger acid and predict whether reactants or products are favoured.

	Stronger Acid	Side Favoured
A.	HNO_2	reactants
B.	HNO_2	products
C.	C_6H_5COOH	reactants
D.	C_6H_5COOH	products

27. Which of the following represents the equilibrium expression for the ionization of water? **(1 mark)**

A. $K_w = [H_3O^+][OH^-]$

B. $K_w = \dfrac{1}{[H_3O^+][OH^-]}$

C. $K_w = [H_3O^+] + [OH^-]$

D. $K_w = \dfrac{[H_3O^+][OH^-]}{[H_2O]}$

28. Determine the pH of $3.0\,M$ KOH . **(2 marks)**

A.   0.48
B.   11.00
C.   13.52
D.   14.48

29. Four acids are analyzed and their K_a values are determined. Which of the following values represents the strongest acid? **(1 mark)**
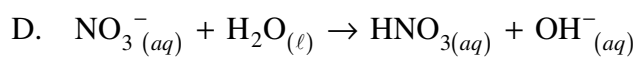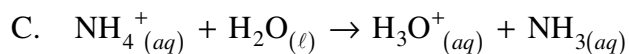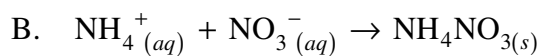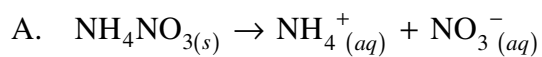
    A. $K_a = 2.2 \times 10^{-13}$

    B. $K_a = 6.2 \times 10^{-8}$

    C. $K_a = 1.7 \times 10^{-5}$

    D. $K_a = 1.2 \times 10^{-2}$

30. The dissociation of NH_4NO_3 is represented by **(1 mark)**

    A. $NH_4NO_{3(s)} \rightarrow NH_4^+{}_{(aq)} + NO_3^-{}_{(aq)}$

    B. $NH_4^+{}_{(aq)} + NO_3^-{}_{(aq)} \rightarrow NH_4NO_{3(s)}$

    C. $NH_4^+{}_{(aq)} + H_2O_{(\ell)} \rightarrow H_3O^+{}_{(aq)} + NH_{3(aq)}$

    D. $NO_3^-{}_{(aq)} + H_2O_{(\ell)} \rightarrow HNO_{3(aq)} + OH^-{}_{(aq)}$

31. A solution of $Al(NO_3)_3$ will be **(1 mark)**

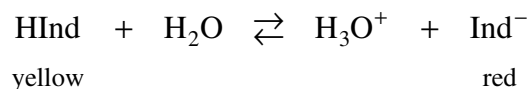   A. basic.
    B. acidic.
    C. neutral.
    D. amphiprotic.

32. Consider the following equilibrium for the chemical indicator phenol red, HInd,
at a $pH = 7.3$ (orange) . **(2 marks)**

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

yellow   red

When some NaOH is added, what stress is imposed on the equilibrium and what colour change occurs?

	Stress	Indicator Colour Change
A.	increased $[H_3O^+]$	turns red
B.	decreased $[H_3O^+]$	turns red
C.	increased $[H_3O^+]$	turns yellow
D.	decreased $[H_3O^+]$	turns yellow

33. A chemical indicator has a $K_a = 2.5 \times 10^{-5}$. Determine the pH at the transition point. **(1 mark)**

A. 2.30
B. 4.60
C. 7.00
D. 9.40

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34. Consider the following titration curve:

mol of added base
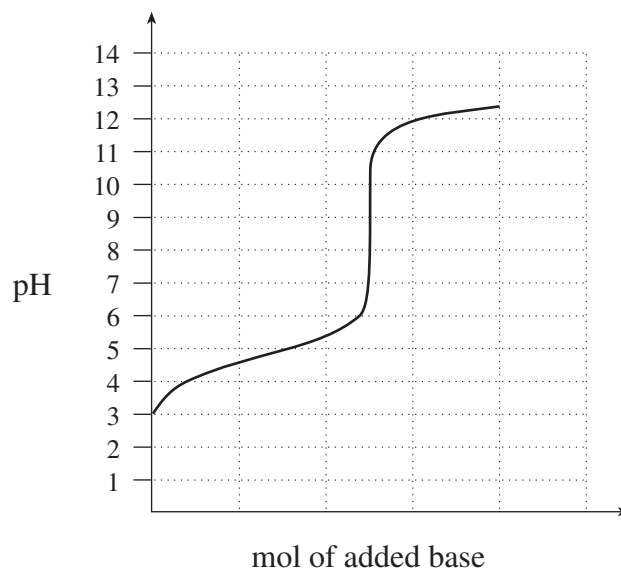
Select a suitable indicator for this titration. **(1 mark)**

A. orange IV
B. methyl red
C. thymolphthalein
D. indigo carmine

35. Calculate the volume of $0.300\,M$ HNO_3 needed to completely neutralize $25.0\,mL$ of $0.250\,M$ $Sr(OH)_2$. **(2 marks)**

A. $10.4\,mL$
B. $15.0\,mL$
C. $20.8\,mL$
D. $41.7\,mL$

36. Equal moles of which of the following chemicals could be used to make a basic buffer solution? **(1 mark)**

A. HF and $NaOH$

B. HCl and $NaCl$

C. KBr and $NaNO_3$

D. NH_3 and NH_4Cl

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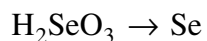
37. Which reaction occurs when calcium oxide is added to water? **(1 mark)**

A. $2CaO_{(s)} \rightarrow Ca_2O_{2(aq)}$

B. $2CaO_{(s)} \rightarrow 2Ca_{(aq)} + O_{2(aq)}$

C. $CaO_{(s)} + H_2O_{(\ell)} \rightarrow Ca(OH)_{2(aq)}$

D. $CaO_{(s)} + H_2O_{(\ell)} \rightarrow CaOH_{(aq)} + O_{2(aq)}$

38. Which of the following is the strongest reducing agent? **(1 mark)**

A. H_2S

B. H_2O

C. H_2Se

D. H_2Te

39. Consider the following unbalanced half-reaction: **(2 marks)**

$$H_2SeO_3 \rightarrow Se$$

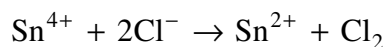The oxidation number of Se

A. increases as it undergoes oxidation.
B. increases as it undergoes reduction.
C. decreases as it undergoes oxidation.
D. decreases as it undergoes reduction.

40. Which of the following will react spontaneously with Br_2 but not with I_2 ? **(1 mark)**

    A. F^-
    B. Cr^{2+}
    C. Fe^{2+}
    D. Mn^{2+}

41. Consider the following: **(1 mark)**

$$Sn^{4+} + 2Cl^- \rightarrow Sn^{2+} + Cl_2$$

What is true for this reaction?

    A. $E^°_{cell} = +1.51\,V$ and it is spontaneous.

    B. $E^°_{cell} = +1.21\,V$ and it is spontaneous.

    C. $E^°_{cell} = -1.21\,V$ and it is non-spontaneous.

    D. $E^°_{cell} = -1.51\,V$ and it is non-spontaneous.

42. What is the function of the salt bridge in an electrochemical cell? **(1 mark)**

    A. It provides a path for electrons.
    B. It maintains electrical neutrality in each half cell.
    C. It allows the anode to become positively charged.
    D. It allows the cathode to become negatively charged.

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Use the following diagram to answer questions 43, 44 and 45.
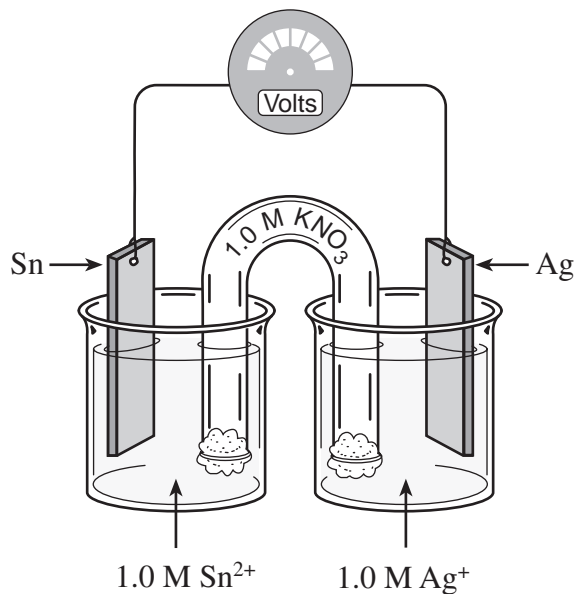
43. In the above electrochemical cell, how do the mass of the anode and the $\left[Ag^+\right]$ change as the cell operates? **(2 marks)**

	Mass of the Anode	$\left[Ag^+\right]$
A.	decreases	increases
B.	increases	increases
C.	decreases	decreases
D.	no change	decreases

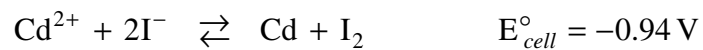44. What is the overall cell reaction? **(1 mark)**

    A. $2Ag + Sn^{2+} \rightarrow Sn + 2Ag^+$

    B. $2Ag + Sn \rightarrow Sn^{2+} + 2Ag^+$

    C. $2Ag^+ + Sn^{2+} \rightarrow Sn + 2Ag$

    D. $2Ag^+ + Sn \rightarrow Sn^{2+} + 2Ag$

45. What is the value of $E°$ for the cell? **(1 mark)**

    A. -0.94 V

    B. -0.66 V

    C. $+0.66$ V

    D. $+0.94$ V

46. Consider the following equation: **(1 mark)**

$$Cd^{2+} + 2I^- \rightleftarrows Cd + I_2 \qquad E^°_{cell} = -0.94 \text{ V}$$

What is $E^°$ for the reduction of Cd^{2+} ?

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

47. Which of the following describes an operating electrochemical cell? **(2 marks)**

	$E^°$	Type of Reaction	Direction of Electron Flow
A.	positive	spontaneous	anode to cathode
B.	negative	spontaneous	cathode to anode
C.	positive	non-spontaneous	anode to cathode
D.	negative	non-spontaneous	cathode to anode

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48. A copper spoon is plated with silver in an electrolytic cell.
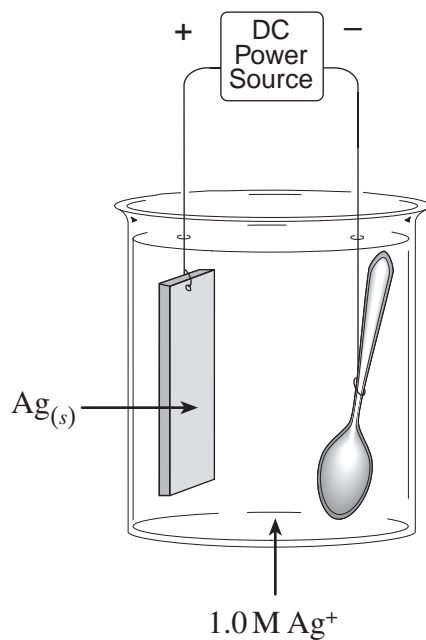
What is the reaction at the anode? **(1 mark)**

A. $Ag \rightarrow Ag^+ + e^-$

B. $Ag^+ + e^- \rightarrow Ag$

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

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

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

| **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 calculations, full marks will NOT be given for providing only an answer.

1. Consider the reaction: **(3 marks)**

$$2Al_{(s)} + 6HCl_{(aq)} \rightarrow 2AlCl_{3(aq)} + 3H_{2(g)}$$
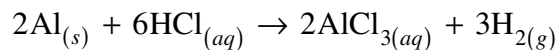
A 10.0 g sample of Al reacts completely in excess HCl in 300.0 s.
What is the rate of production of H_2 in mol/s ?

2. Using collision theory, give **two** reasons why reactions occur more rapidly at a higher temperature. **(2 marks)**

i) _____

_____

ii) _____

_____

3. Chemical reactions tend toward a position of minimum enthalpy and maximum entropy.

a) What is meant by the term *enthalpy*? **(1 mark)**

_____

b) What is meant by the term *entropy*? **(1 mark)**

_____

4. Consider the following: **(4 marks)**

$$H_{2(g)} + Br_{2(g)} \rightleftarrows 2HBr_{(g)} \qquad K_{eq} = 12.0$$

Initially, $0.080\,\text{mol } H_2$ and $0.080\,\text{mol } Br_2$ are placed into a $4.00\,\text{L}$ container. What is the $[HBr]$ at equilibrium?

5. Consider the following equilibrium and accompanying graph:

$$Zn(IO_3)_{2(s)} \rightleftarrows Zn^{2+}_{(aq)} + 2IO_3^-{}_{(aq)}$$
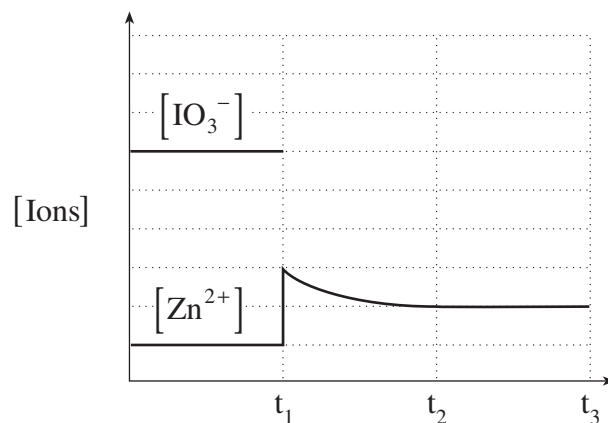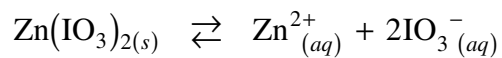
a) Identify the stress applied at t_1 .   **(1 mark)**

b) Complete the above graph from t_1 to t_3 for the $\left[IO_3^-\right]$.   **(2 marks)**

6. Calculate the solubility of $SrSO_4$ in grams per litre.   **(3 marks)**

7. The cyanide ion, CN^-, is a Brønsted-Lowry base.

    a) Define *Brønsted-Lowry base*.   **(1 mark)**

    _____

    _____

    b) Write the equation representing the reaction of CN^- with water.   **(2 marks)**

    c) Identify a conjugate pair in b) above.   **(1 mark)**

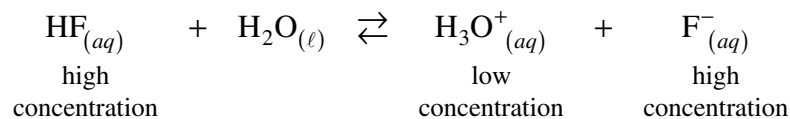8. Write an equation to show the ionization of water.   **(2 marks)**

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9. Calculate the pH of $1.50\,\text{M}\ NH_3$. **(5 marks)**

10. Consider the following buffer equilibrium: **(3 marks)**

$$HF_{(aq)} \quad + \quad H_2O_{(\ell)} \quad \rightleftarrows \quad H_3O^+_{(aq)} \quad + \quad F^-_{(aq)}$$

    high   low   high
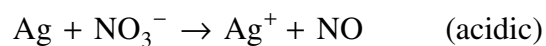
concentration   concentration   concentration

Using Le Châtelier's Principle, explain what happens to the pH of the buffer solution when a small amount of NaOH is added.

11. Balance the following redox equation: **(4 marks)**

$$Ag + NO_3^- \rightarrow Ag^+ + NO \qquad \text{(acidic)}$$

OVER

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12. Draw a diagram of an operating electrolytic cell used to extract pure lead from an impure lead sample. Identify the electrolyte and the material used for the anode. **(3 marks)**

13. A sample of copper is placed in $HNO_{3(aq)}$ and another sample of copper is placed in $HCl_{(aq)}$.

a) In which acid does the copper react? $\left(\frac{1}{2} \textbf{ mark}\right)$

_____

b) Calculate $E°$ for the reaction that occurs. $\left(1\frac{1}{2} \textbf{ marks}\right)$

END OF EXAMINATION