INSERT STUDENT I.D. NUMBER (PEN)

STICKER IN THIS SPACE

JANUARY 1999

PROVINCIAL EXAMINATION

MINISTRY OF EDUCATION

CHEMISTRY 12

GENERAL INSTRUCTIONS

1. Insert the stickers with your Student I.D. Number (PEN) in the allotted spaces above and on the **back** cover of this booklet. **Under no circumstance is your name or identification, other than your Student I.D. 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. All multiple-choice answers must be entered on the Response Form using an **HB pencil**. Multiple-choice answers entered in this examination booklet will **not** be marked.
5. For each of the written-response questions, write your answer in the space provided in this booklet.
6. 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 .
7. 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.

CHEMISTRY 12 PROVINCIAL EXAMINATION

1. This examination consists of **two** parts:

		Value	**Suggested Time**
PART A:	48 multiple-choice questions	48	70
PART B:	9 written-response questions	32	50
	Total:	**80 marks**	**120 minutes**

2. Aside from an approved calculator, electronic devices, including dictionaries and pagers, are **not** permitted in the examination room.

3. The following tables can be found in the separate **Data Booklet**.
   - Periodic Table of the Elements
   - Atomic Masses of the Elements
   - Names, Formulae, and Charges of Some Common Ions
   - Solubility of Common Compounds in Water
   - 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.

4. **A calculator is essential for the Chemistry 12 Provincial Examination.** The calculator must be a hand-held device designed primarily for mathematical computations involving logarithmic and trigonometric functions and may also include graphing functions. Computers, calculators with a QWERTY keyboard, and electronic writing pads will not be allowed. Students must not bring any external support devices such as manuals, printed or electronic cards, printers, memory expansion chips, or external keyboards. Students may have more than one calculator available during the examination, but calculators may not be shared. Communication between calculators is prohibited and calculators must not have the ability to either transmit or receive electronic signals. In addition to an approved calculator, students will be allowed to use rulers, compasses, and protractors during the examination.

5. The time allotted for this examination is **two hours**.

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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 Response Form provided. Using an HB pencil, completely fill in the circle that has the letter corresponding to your answer.

1. Consider the reaction:

$$\mathrm{Ca}_{(s)} + 2\mathrm{H_2O}_{(\ell)} \rightarrow \mathrm{Ca(OH)}_{2(aq)} + \mathrm{H}_{2(g)}$$

At a certain temperature, $2.50\,\mathrm{g\ Ca}$ reacts completely in 30.0 seconds. The rate of consumption of Ca is

A. 0.00208 mol/min
B. 0.0833 mol/min
C. 0.125 mol/min
D. 5.00 mol/min

2. The minimum amount of energy required to overcome the energy barrier in a chemical reaction is the

A. heat of reaction.
B. activation energy.
C. KE of the reactants.
D. enthalpy of the products.

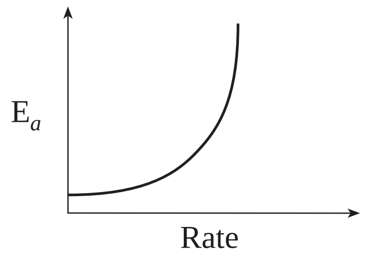
3. An activated complex is a chemical species that is

A. stable and has low PE.
B. stable and has high PE.
C. unstable and has low PE.
D. unstable and has high PE.

OVER

4. A certain reaction is able to proceed by various mechanisms. Each mechanism has a different E_a and results in a different overall rate. Which of the following best describes the relationship between the E_a values and the rates?

A.



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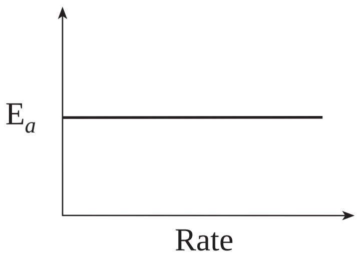

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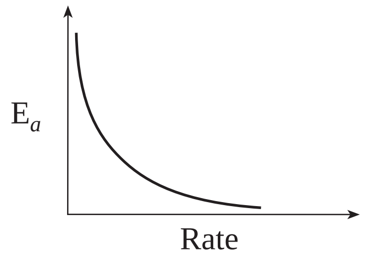

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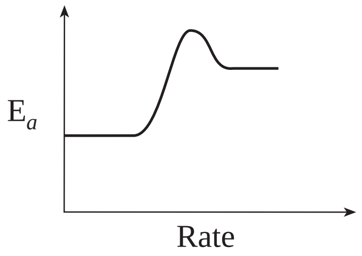
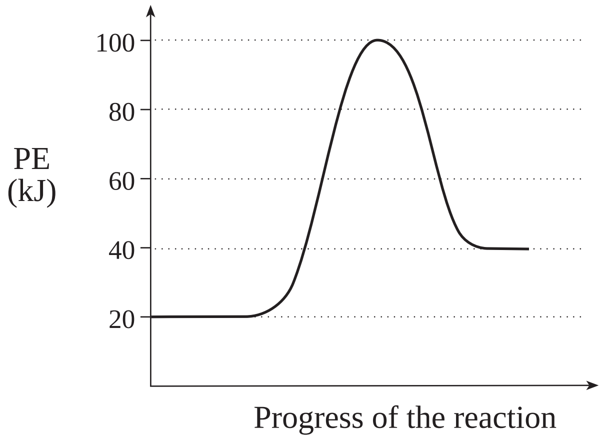


5. Consider the following PE diagram:



The forward reaction can be described as

	ΔH (kJ)	Activation Energy (kJ)	Type of Reaction
A.	+20	80	endothermic
B.	+20	60	exothermic
C.	–20	80	exothermic
D.	–20	100	endothermic

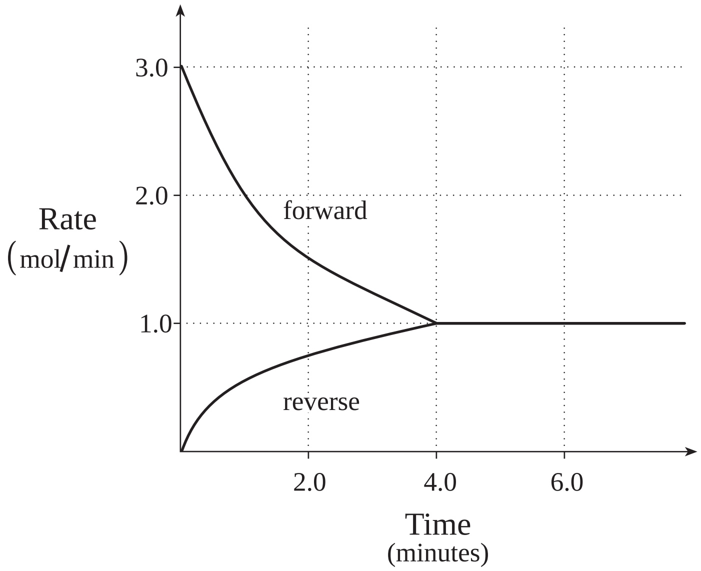
6. Consider the following reaction mechanism:

Step 1	$2NO + H_2 \rightarrow N_2 + H_2O_2$
Step 2	$H_2O_2 + H_2 \rightarrow 2H_2O$

In this reaction, H_2 is a

A. product.
B. catalyst.
C. reactant.
D. reaction intermediate.

7. Consider the following graph:



When equilibrium is reached, the rate of the forward reaction is

A. $0.00\ \text{mol/min}$
B. $0.25\ \text{mol/min}$
C. $1.0\ \text{mol/min}$
D. $3.0\ \text{mol/min}$

8. Consider the following equilibrium:

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

The equilibrium will shift to the left as a result of

A. adding a catalyst.
B. increasing the volume.
C. removing some N_2O_4.
D. decreasing the temperature.

9. Ethene, C_2H_4, can be produced in the following industrial system:

$$C_2H_{6(g)} + \text{energy} \rightleftarrows C_2H_{4(g)} + H_{2(g)}$$

The conditions that are necessary to maximize the equilibrium yield of C_2H_4 are

A. low temperature and low pressure.
B. low temperature and high pressure.
C. high temperature and low pressure.
D. high temperature and high pressure.

10. Consider the following equilibrium:

$$H_{2(g)} + I_{2(g)} \rightleftarrows 2HI_{(g)}$$

The volume of the equilibrium system is increased and a new equilibrium is established. Compared to the rates in the original equilibrium, which of the following describes the rates of the forward and reverse reactions in the new equilibrium?

	FORWARD RATE	REVERSE RATE
A.	decreased	decreased
B.	increased	increased
C.	decreased	increased
D.	remained constant	remained constant

11. Consider the following equilibrium:

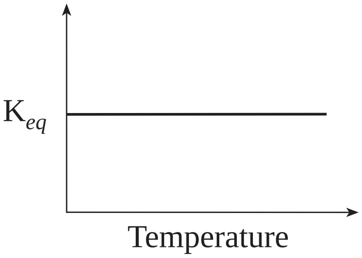
$$N_{2(g)} + 3H_{2(g)} \rightleftarrows 2NH_{3(g)} + \text{energy}$$

Certain conditions provide less than 10% yield of NH_3 at equilibrium. Which of the following describes this equilibrium?

	K_{eq}	EQUILIBRIUM POSITION
A.	large	favours products
B.	small	favours products
C.	large	favours reactants
D.	small	favours reactants

12. Which of the following best describes the relationship between K_{eq} and temperature for an endothermic reaction?

A.



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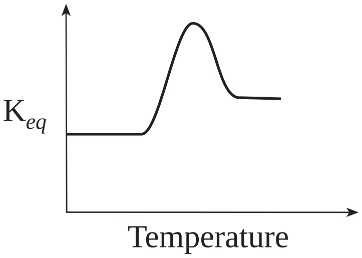
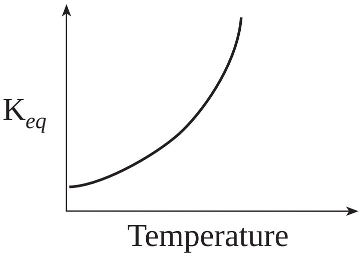


C.



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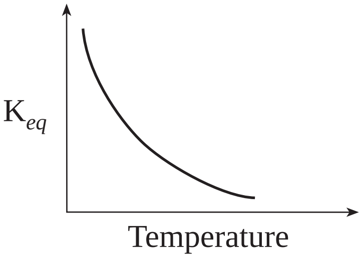


13. Consider the following equilibrium:

$$CO_{(g)} + 2H_{2(g)} \rightleftarrows CH_3OH_{(g)} \qquad K_{eq} = 12.0$$

At equilibrium, a $1.00\,L$ flask contains $0.020\,mol$ CO and $0.35\,mol$ H_2.
What is the concentration of CH_3OH at equilibrium?

A. 2.0×10^{-4} mol/L
B. 5.8×10^{-4} mol/L
C. 2.9×10^{-2} mol/L
D. 8.4×10^{-2} mol/L

14. Which of the following units could be used to describe solubility?

A. g/s
B. g/L
C. M/L
D. mol/s

15. Consider the following anions:

	ANION
I.	$10.0\,mL$ of $0.20\,M$ Cl^-
II.	$10.0\,mL$ of $0.20\,M$ OH^-
III.	$10.0\,mL$ of $0.20\,M$ SO_3^{2-}

When $10.0\,mL$ of $0.20\,M$ $Pb(NO_3)_2$ are added to each of the above, precipitates form in

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

16. When equal volumes of $0.20\,\mathrm{M}$ $\mathrm{CuSO_4}$ and $0.20\,\mathrm{M}$ $\mathrm{Li_2S}$ are combined, the complete ionic equation is

A. $\mathrm{Cu^{2+}}_{(aq)} + \mathrm{S^{2-}}_{(aq)} \rightarrow \mathrm{CuS}_{(s)}$

B. $\mathrm{CuSO}_{4(aq)} + \mathrm{Li_2S}_{(aq)} \rightarrow \mathrm{CuS}_{(s)} + \mathrm{Li_2SO}_{4(aq)}$

C. $\mathrm{Cu^{2+}}_{(aq)} + \mathrm{SO_4}^{2-}{}_{(aq)} + 2\,\mathrm{Li^{+}}_{(aq)} + \mathrm{S^{2-}}_{(aq)} \rightarrow \mathrm{Li_2SO}_{4(aq)} + \mathrm{CuS}_{(s)}$

D. $\mathrm{Cu^{2+}}_{(aq)} + \mathrm{SO_4}^{2-}{}_{(aq)} + 2\,\mathrm{Li^{+}}_{(aq)} + \mathrm{S^{2-}}_{(aq)} \rightarrow \mathrm{CuS}_{(s)} + 2\,\mathrm{Li^{+}}_{(aq)} + \mathrm{SO_4}^{2-}{}_{(aq)}$

17. The K_{sp} expression for a saturated solution of $\mathrm{Ag_2CO_3}$ is

A. $\mathrm{K}_{sp} = \left[\mathrm{Ag_2}^{+}\right]\left[\mathrm{CO_3}^{2-}\right]$

B. $\mathrm{K}_{sp} = \left[\mathrm{Ag^{+}}\right]^2\left[\mathrm{CO_3}^{2-}\right]$

C. $\mathrm{K}_{sp} = \left[2\,\mathrm{Ag^{+}}\right]\left[\mathrm{CO_3}^{2-}\right]$

D. $\mathrm{K}_{sp} = \left[2\,\mathrm{Ag^{+}}\right]^2\left[\mathrm{CO_3}^{2-}\right]$

18. The solubility of $\mathrm{FeF_2}$ is $8.4\times10^{-3}\,\mathrm{M}$. The K_{sp} value is

A. 5.9×10^{-7}

B. 2.4×10^{-6}

C. 7.1×10^{-5}

D. 8.4×10^{-3}

19. If the Trial Ion Product for $\mathrm{AgBrO_3}$ is calculated to be 1.0×10^{-7}, then

A. a precipitate forms because the Trial Ion Product > K_{sp}

B. a precipitate forms because the Trial Ion Product < K_{sp}

C. no precipitate forms because the Trial Ion Product > K_{sp}

D. no precipitate forms because the Trial Ion Product < K_{sp}

OVER

20. The least soluble salt in water is

A. CaS

B. $CaSO_4$

C. CaC_2O_4

D. $Ca(NO_3)_2$

21. Consider the following acid-base equilibrium:

$$HCO_3^- + H_2O \rightleftarrows H_2CO_3 + OH^-$$

In the reaction above, the Brönsted-Lowry acids are

A. H_2O and OH^-

B. HCO_3^- and OH^-

C. H_2O and H_2CO_3

D. HCO_3^- and H_2CO_3

22. Consider the following solubility equilibrium:

$$Mg(OH)_{2(s)} \rightleftarrows Mg^{2+}_{(aq)} + 2OH^-_{(aq)}$$

A compound that could be added to cause this equilibrium to shift to the right is

A. Na_2O

B. NH_4Cl

C. $Sr(OH)_2$

D. $Mg(OH)_2$

23. The solution with the lowest electrical conductivity is

A. $0.10\,M\ H_2S$

B. $0.10\,M\ HNO_2$

C. $0.10\,M\ H_2SO_3$

D. $0.10\,M\ NH_4Cl$

24. The solution with the lowest pH is

A. $1.0\,\mathrm{M}$ HF
B. $1.0\,\mathrm{M}$ HCN
C. $1.0\,\mathrm{M}$ HCOOH
D. $1.0\,\mathrm{M}$ CH_3COOH

25. As the $\left[H_3O^+\right]$ in a solution decreases, the $\left[OH^-\right]$

A. increases and the pH increases.
B. increases and the pH decreases.
C. decreases and the pH increases.
D. decreases and the pH decreases.

26. The value of pK_w at $25°C$ is

A. 1.0×10^{-14}
B. 1.0×10^{-7}
C. 7.00
D. 14.00

27. Consider the following equilibrium:

$$2H_2O + \text{energy} \rightleftarrows H_3O^+ + OH^-$$

In pure water at a temperature of $50°C$,

A. $pH < 7$
B. $pH + pOH = 14$
C. $K_w = 1.0\times10^{-14}$
D. $\left[OH^-\right] < 1.0\times10^{-7}$

OVER

28. What is the pOH of 2.5 M NaOH?

A. -0.40

B. 0.0032

C. 0.40

D. 13.60

29. A $0.010\,\mathrm{M}$ acid solution has a pH of 2.00. The acid could be

A. HNO_3

B. H_2SO_3

C. $HCOOH$

D. CH_3COOH

30. Which of the following salts dissolves to produce a basic aqueous solution?

A. LiF

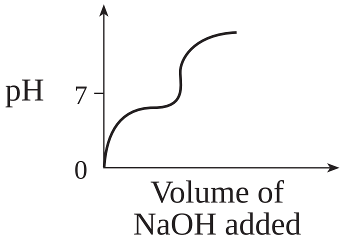
B. $KClO_4$

C. $NaHSO_3$

D. NH_4NO_3

31. Which titration curve represents the titration of HCl with NaOH?

A.



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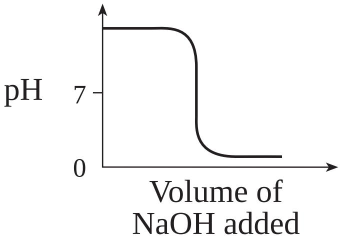
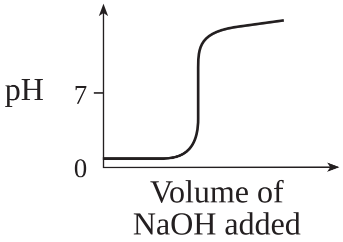


C.



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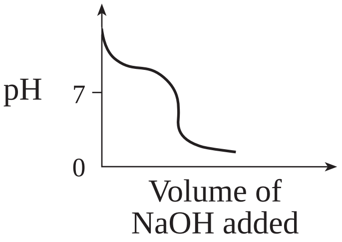


32. A buffer solution can be formed by dissolving equal moles of

A. HF and NaF
B. HCl and NaOH
C. KBr and Na_3PO_4
D. CH_3COOH and NaCl

33. Which of the following gases is a contributor to the formation of acid rain?

A. H_2
B. O_3
C. SO_2
D. NH_3

OVER

34. During a titration, an indicator is found to change colour when the $\left[H_3O^+\right] = 1\times10^{-6}\ \mathrm{M}$. Identify the indicator.

A. methyl violet
B. alizarin yellow
C. phenolphthalein
D. chlorophenol red

35. Consider the following:

I.	PO_4^{3-}
II.	HPO_4^{2-}
III.	$H_2PO_4^{-}$
IV.	H_3PO_4

The term amphiprotic can be used to describe

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

36. Calculate the $\left[H_3O^+\right]$ in a solution prepared by mixing $25.0\,\mathrm{mL}$ of $1.0\,\mathrm{M}$ HCl with $50.0\,\mathrm{mL}$ of $0.50\,\mathrm{M}$ KOH.

A. $1.0\ \mathrm{M}$

B. $0.50\ \mathrm{M}$

C. $0.25\ \mathrm{M}$

D. $1.0\times10^{-7}\ \mathrm{M}$

37. Consider the following redox reaction:

$$2MnO_4^{-} + 3ClO_3^{-} + H_2O \rightarrow 3ClO_4^{-} + 2MnO_2 + 2OH^{-}$$

The reducing agent is

A. H_2O
B. ClO_3^{-}
C. MnO_2
D. MnO_4^{-}

38. Consider the following reaction that occurs in a breathalyzer:

$$2Cr_2O_7{}^{2-}{}_{(aq)} + 16H^{+}{}_{(aq)} + 3C_2H_5OH_{(g)} \rightarrow 4Cr^{3+}{}_{(aq)} + 11H_2O_{(l)} + 3CH_3COOH_{(aq)}$$

Which atom undergoes an increase in oxidation number?

A. carbon
B. oxygen
C. hydrogen
D. chromium

39. Which of the following is the strongest reducing agent?

A. Al
B. Cu
C. Zn
D. Mg

40. Which of the following reactions is spontaneous at standard conditions?

A. $Pb + Cu^{2+} \rightarrow Cu + Pb^{2+}$
B. $H_2 + Mg^{2+} \rightarrow Mg + 2H^{+}$
C. $Br_2 + 2Cl^{-} \rightarrow Cl_2 + 2Br^{-}$
D. $2Ag + Cu^{2+} \rightarrow Cu + 2Ag^{+}$

OVER

41. Consider the following redox reaction:

$$3ClO_2^- \rightarrow 2ClO_3^- + Cl^- \qquad (\text{basic})$$

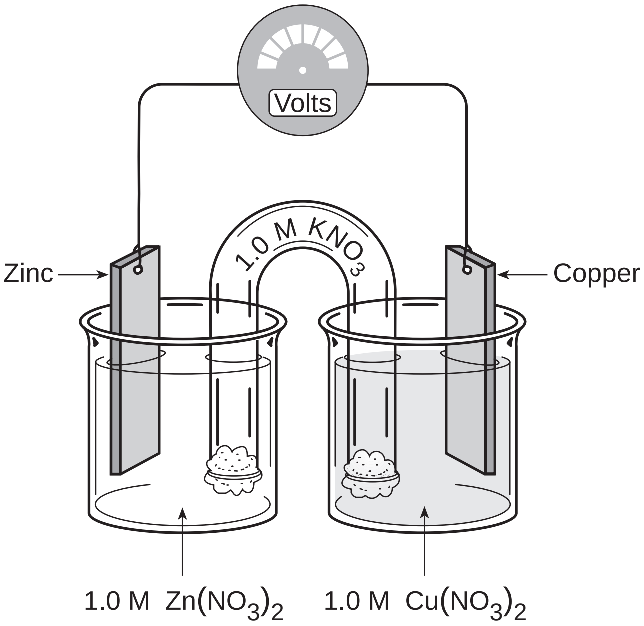
The reduction half-reaction that occurs is

A. $ClO_2^- + 2H_2O + 4e^- \rightarrow Cl^- + 4OH^-$
B. $ClO_2^- + 2H_2O \rightarrow Cl^- + 4OH^- + 4e^-$
C. $ClO_2^- + 2OH^- + 2e^- \rightarrow ClO_3^- + H_2O$
D. $ClO_2^- + 2OH^- \rightarrow ClO_3^- + H_2O + 2e^-$

42. Vanadium metal, V, reacts spontaneously with Cd^{2+}, but not with Ti^{2+}. Based on these results, the order of oxidizing agents, from strongest to weakest, is

A. Cd^{2+}, V^{2+}, Ti^{2+}
B. V^{2+}, Ti^{2+}, Cd^{2+}
C. Ti^{2+}, Cd^{2+}, V^{2+}
D. Ti^{2+}, V^{2+}, Cd^{2+}

43. Consider the following electrochemical cell:



In this operating electrochemical cell,

A. electrons flow toward the Cu and the Cu^{2+} ions migrate toward the Zn.
B. electrons flow toward the Cu and the Zn^{2+} ions migrate toward the Cu.
C. electrons flow toward the Zn and the Cu^{2+} ions migrate toward the Zn.
D. electrons flow toward the Zn and the Zn^{2+} ions migrate toward the Cu.

44. Which of the following affects the potentials of electrochemical cells?

I.	species used as oxidizing agent
II.	temperature
III.	concentration of reactants

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

OVER

45. In the rusting of iron, the reduction reaction that occurs is

A. $Fe \rightarrow Fe^{2+} + 2e^-$

B. $Fe^{2+} + 2e^- \rightarrow Fe$

C . $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$

D. $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

46. During a cathodic protection, the sacrificial anode

A. accepts electrons from the protected metal.
B. reacts spontaneously with the protected metal.
C. oxidizes more readily than the protected metal.
D. causes the protected metal to become an anode.

47. During the electrolysis of an aqueous solution of KI, what substance is formed at the cathode?

A. iodine
B. oxygen
C. hydrogen
D. potassium

48. When electroplating an iron medallion with nickel,

A. the medallion is an anode.

B. the cathode is pure nickel.

C. the solution contains Ni^{2+}.

D. the anode reaction is $Ni^{2+} + 2e^- \rightarrow Ni$

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

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. Consider the following reaction mechanism:

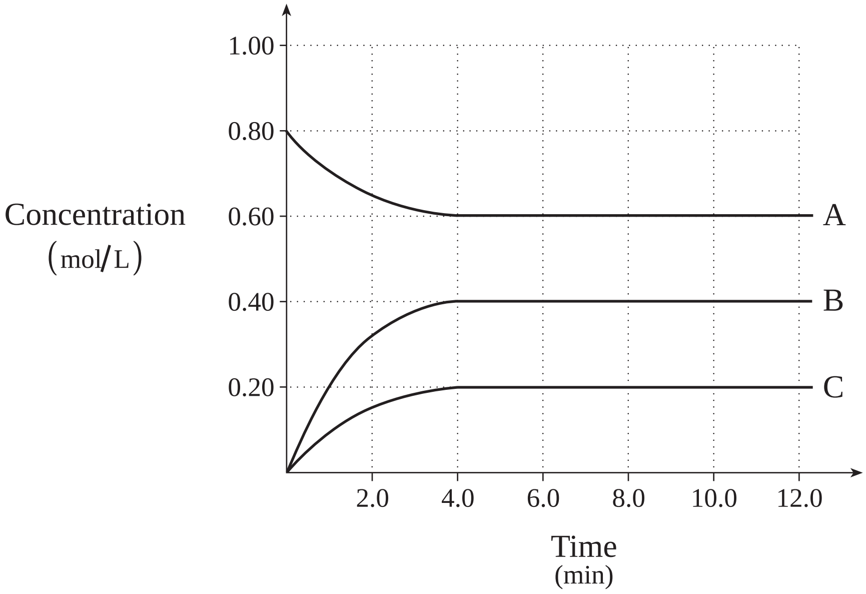
Step 1	?
Step 2	$H_2 + Cl \rightarrow HCl + H$
Step 3	$H + Cl_2 \rightarrow HCl + Cl$
Step 4	$Cl + Cl \rightarrow Cl_2$
Overall	$H_2 + Cl_2 \rightarrow 2HCl$

a) Write the equation for Step 1. **(2 marks)**

b) Identify the reaction intermediate(s). **(1 mark)**

OVER

2. Consider the following diagram for a chemical system containing three substances represented by A, B and C:



a) What feature of the graph indicates that the system reaches equilibrium? **(1 mark)**

b) Write a balanced equation for the equilibrium reaction. **(2 marks)**

c) Calculate K_{eq} at equilibrium. **(2 marks)**

3. In an experiment to determine the solubility of barium fluoride, 500.0 mL of the saturated solution was heated in an evaporating dish to remove the water. The evaporating dish and residue were heated two more times, to ensure all the water had been driven off.

I.	Volume of saturated solution of BaF_2	500.0 mL
II.	Mass of evaporating dish	72.540 g
III.	Mass of evaporating dish and BaF_2 after first heating	73.500 g
IV.	Mass of evaporating dish and BaF_2 after second heating	72.855 g
V.	Mass of evaporating dish and BaF_2 after third heating	72.855 g

Using the data above, calculate the K_{sp} for BaF_2. **(4 marks)**

OVER

4. Consider the salt sodium oxalate, $Na_2C_2O_4$.

a) Write the dissociation equation for sodium oxalate. **(1 mark)**

b) A $1.0\,M$ solution of sodium oxalate turns pink when a few drops of the indicator phenolphthalein are added. Write a hydrolysis equation and explain why this salt causes the indicator to change colour. **(2 marks)**

c) Calculate the equilibrium constant for the hydrolysis in b). **(1 mark)**

5. Calculate the pH of $0.50\,\text{M}\ H_3BO_3$. **(4 marks)**

OVER

6. A $25.0\,\text{mL}$ sample of $Sr(OH)_2$ is titrated with a standardized solution of HCl to the equivalence point.

a) Write the formula equation for the neutralization. **(1 mark)**

b) Write the net ionic equation for the neutralization. **(1 mark)**

c) What is meant by the term “standardized” solution? **(1 mark)**

d) Define *equivalence point*. **(1 mark)**

7. Balance the following redox reaction in acidic solution:

$$RuO_4 + P \rightarrow Ru(OH)_2{}^{2+} + H_3PO_3 \qquad (acid)$$ **(3 marks)**

8. A technician tests the concentration of methanol, CH_3OH, in diluted windshield washer fluid using a redox titration. A $25.00\,\text{mL}$ sample is titrated with $14.50\,\text{mL}$ of $0.0200\,\text{M}$ $KMnO_4$. Determine the concentration of methanol in the sample given the following redox reaction:

$$6H^+ + 2MnO_4^- + 5CH_3OH \rightarrow 5CH_2O + 2Mn^{2+} + 8H_2O$$ **(3 marks)**

9. An electrolytic cell can be used to plate a copper penny with a silver coating. Sketch a diagram of the electrolytic cell. Label the cathode and show the direction of electron flow. **(2 marks)**

END OF EXAMINATION

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STICKER IN THIS SPACE

CHEMISTRY 12

January 1999

Course Code = CH

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CHEMISTRY 12

January 1999

Course Code = CH

Score for Question 1:

1. ______ (3)

Score for Question 2:

2. ______ (5)

Score for Question 3:

3. ______ (4)

Score for Question 4:

4. ______ (4)

Score for Question 5:

5. ______ (4)

Score for Question 6:

6. ______ (4)

Score for Question 7:

7. ______ (3)

Score for Question 8:

8. ______ (3)

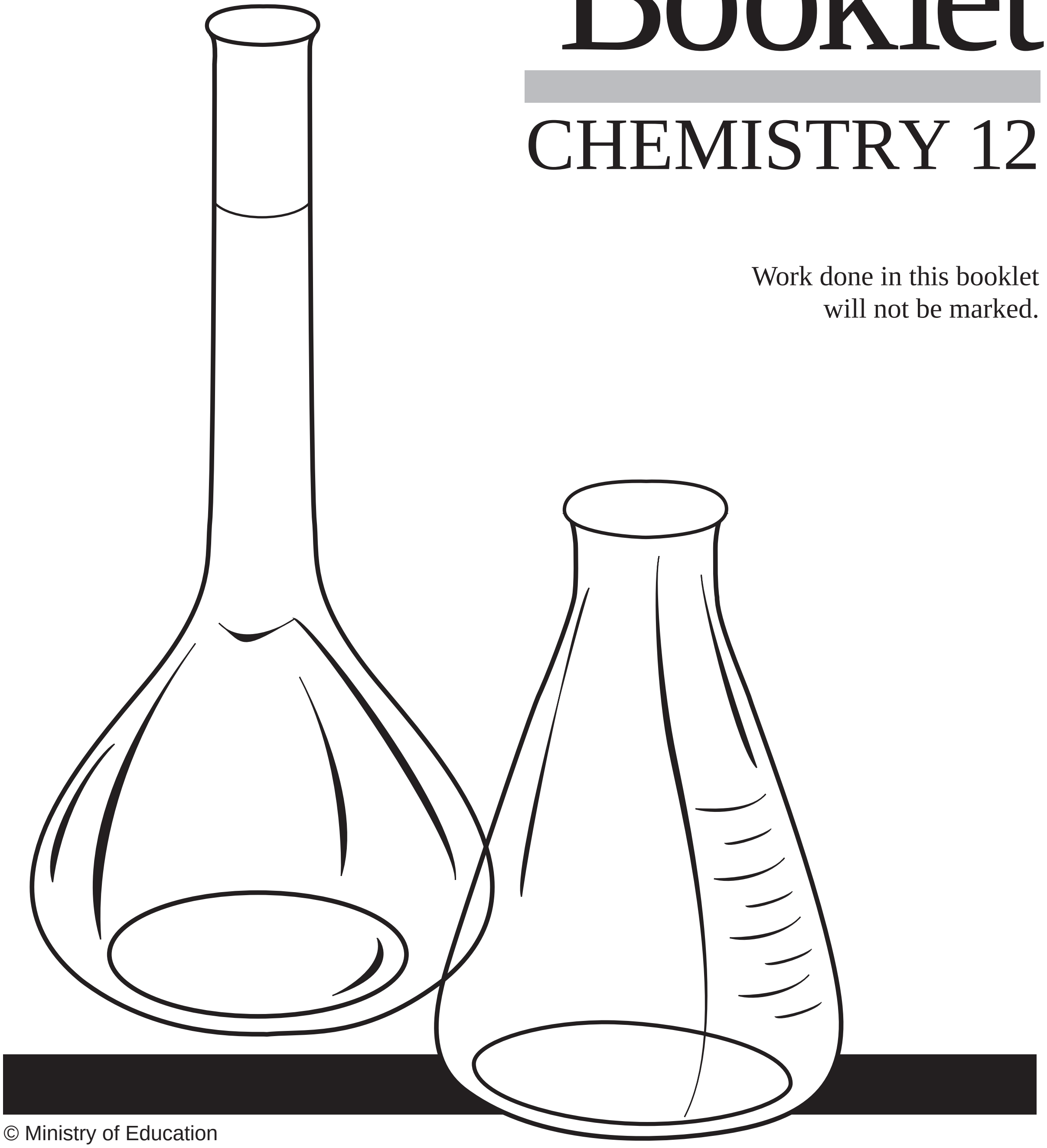
Score for Question 9:

9. ______ (2)

Data Booklet

CHEMISTRY 12

Work done in this booklet
will not be marked.



Revised November 1994

CONTENTS

REFERENCE

D.R. Lide, *CRC Handbook of Chemistry and Physics*, 74 edition, CRC Press, Boca Raton, 1993.

PERIODIC TABLE OF THE ELEMENTS

14	Atomic number
Si	Symbol
Silicon	Name
28.1	Atomic mass

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1.0																	2 He Helium 4.0
3 Li Lithium 6.9	4 Be Beryllium 9.0											5 B Boron 10.8	6 C Carbon 12.0	7 N Nitrogen 14.0	8 O Oxygen 16.0	9 F Fluorine 19.0	10 Ne Neon 20.2
11 Na Sodium 23.0	12 Mg Magnesium 24.3											13 Al Aluminum 27.0	14 Si Silicon 28.1	15 P Phosphorus 31.0	16 S Sulphur 32.1	17 Cl Chlorine 35.5	18 Ar Argon 39.9
19 K Potassium 39.1	20 Ca Calcium 40.1	21 Sc Scandium 45.0	22 Ti Titanium 47.9	23 V Vanadium 50.9	24 Cr Chromium 52.0	25 Mn Manganese 54.9	26 Fe Iron 55.8	27 Co Cobalt 58.9	28 Ni Nickel 58.7	29 Cu Copper 63.5	30 Zn Zinc 65.4	31 Ga Gallium 69.7	32 Ge Germanium 72.6	33 As Arsenic 74.9	34 Se Selenium 79.0	35 Br Bromine 79.9	36 Kr Krypton 83.8
37 Rb Rubidium 85.5	38 Sr Strontium 87.6	39 Y Yttrium 88.9	40 Zr Zirconium 91.2	41 Nb Niobium 92.9	42 Mo Molybdenum 95.9	43 Tc Technetium (98)	44 Ru Ruthenium 101.1	45 Rh Rhodium 102.9	46 Pd Palladium 106.4	47 Ag Silver 107.9	48 Cd Cadmium 112.4	49 In Indium 114.8	50 Sn Tin 118.7	51 Sb Antimony 121.8	52 Te Tellurium 127.6	53 I Iodine 126.9	54 Xe Xenon 131.3
55 Cs Cesium 132.9	56 Ba Barium 137.3	57 La Lanthanum 138.9	72 Hf Hafnium 178.5	73 Ta Tantalum 180.9	74 W Tungsten 183.8	75 Re Rhenium 186.2	76 Os Osmium 190.2	77 Ir Iridium 192.2	78 Pt Platinum 195.1	79 Au Gold 197.0	80 Hg Mercury 200.6	81 Tl Thallium 204.4	82 Pb Lead 207.2	83 Bi Bismuth 209.0	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Ha Hahnium (262)	106 Sg Seaborgium (263)	107 Uns Unnilseptium (262)	108 Uno Unniloctium (265)	109 Une Unnilennium (266)									

58 Ce Cerium 140.1	59 Pr Praseodymium 140.9	60 Nd Neodymium 144.2	61 Pm Promethium (145)	62 Sm Samarium 150.4	63 Eu Europium 152.0	64 Gd Gadolinium 157.3	65 Tb Terbium 158.9	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9	68 Er Erbium 167.3	69 Tm Thulium 168.9	70 Yb Ytterbium 173.0	71 Lu Lutetium 175.0
90 Th Thorium 232.0	91 Pa Protactinium 231.0	92 U Uranium 238.0	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

Based on mass of C^{12} at 12.00.

Values in parentheses are the masses of the most stable or best known isotopes for elements which do not occur naturally.

ATOMIC MASSES OF THE ELEMENTS

Based on mass of C^{12} at 12.00. Values in parentheses are the mass of the most stable or best known isotopes for elements which do not occur naturally.

Element	Symbol	Atomic Number	Atomic Mass
Actinium	Ac	89	(227)
Aluminum	Al	13	27.0
Americium	Am	95	(243)
Antimony	Sb	51	121.8
Argon	Ar	18	39.9
Arsenic	As	33	74.9
Astatine	At	85	(210)
Barium	Ba	56	137.3
Berkelium	Bk	97	(247)
Beryllium	Be	4	9.0
Bismuth	Bi	83	209.0
Boron	B	5	10.8
Bromine	Br	35	79.9
Cadmium	Cd	48	112.4
Calcium	Ca	20	40.1
Californium	Cf	98	(251)
Carbon	C	6	12.0
Cerium	Ce	58	140.1
Cesium	Cs	55	132.9
Chlorine	Cl	17	35.5
Chromium	Cr	24	52.0
Cobalt	Co	27	58.9
Copper	Cu	29	63.5
Curium	Cm	96	(247)
Dysprosium	Dy	66	162.5
Einsteinium	Es	99	(252)
Erbium	Er	68	167.3
Europium	Eu	63	152.0
Fermium	Fm	100	(257)
Fluorine	F	9	19.0
Francium	Fr	87	(223)
Gadolinium	Gd	64	157.3
Gallium	Ga	31	69.7
Germanium	Ge	32	72.6
Gold	Au	79	197.0
Hafnium	Hf	72	178.5
Hahnium	Ha	105	(262)
Helium	He	2	4.0
Holmium	Ho	67	164.9
Hydrogen	H	1	1.0
Indium	In	49	114.8
Iodine	I	53	126.9
Iridium	Ir	77	192.2
Iron	Fe	26	55.8
Krypton	Kr	36	83.8
Lanthanum	La	57	138.9
Lawrencium	Lr	103	(262)
Lead	Pb	82	207.2
Lithium	Li	3	6.9
Lutetium	Lu	71	175.0
Magnesium	Mg	12	24.3
Manganese	Mn	25	54.9
Mendelevium	Md	101	(258)
Mercury	Hg	80	200.6
Molybdenum	Mo	42	95.9
Neodymium	Nd	60	144.2
Neon	Ne	10	20.2
Neptunium	Np	93	(237)
Nickel	Ni	28	58.7
Niobium	Nb	41	92.9
Nitrogen	N	7	14.0
Nobelium	No	102	(259)
Osmium	Os	76	190.2
Oxygen	O	8	16.0
Palladium	Pd	46	106.4
Phosphorus	P	15	31.0
Platinum	Pt	78	195.1
Plutonium	Pu	94	(244)
Polonium	Po	84	(209)
Potassium	K	19	39.1
Praseodymium	Pr	59	140.9
Promethium	Pm	61	(145)
Protactinium	Pa	91	231.0
Radium	Ra	88	(226)
Radon	Rn	86	(222)
Rhenium	Re	75	186.2
Rhodium	Rh	45	102.9
Rubidium	Rb	37	85.5
Ruthenium	Ru	44	101.1
Rutherfordium	Rf	104	(261)
Samarium	Sm	62	150.4
Scandium	Sc	21	45.0
Selenium	Se	34	79.0
Silicon	Si	14	28.1
Silver	Ag	47	107.9
Sodium	Na	11	23.0
Strontium	Sr	38	87.6
Sulphur	S	16	32.1
Tantalum	Ta	73	180.9
Technetium	Tc	43	(98)
Tellurium	Te	52	127.6
Terbium	Tb	65	158.9
Thallium	Tl	81	204.4
Thorium	Th	90	232.0
Thulium	Tm	69	168.9
Tin	Sn	50	118.7
Titanium	Ti	22	47.9
Tungsten	W	74	183.8
Uranium	U	92	238.0
Vanadium	V	23	50.9
Xenon	Xe	54	131.3
Ytterbium	Yb	70	173.0
Yttrium	Y	39	88.9
Zinc	Zn	30	65.4
Zirconium	Zr	40	91.2

NAMES, FORMULAE, AND CHARGES OF SOME COMMON IONS

Positive ions (cations)	
Aluminum	Al^{3+}
Ammonium	NH_4^+
Barium	Ba^{2+}
Calcium	Ca^{2+}
Chromium(II), chromous	Cr^{2+}
Chromium(III), chromic	Cr^{3+}
Copper(I)*, cuprous	Cu^+
Copper(II), cupric	Cu^{2+}
Hydrogen	H^+
Hydronium	H_3O^+
Iron(II)*, ferrous	Fe^{2+}
Iron(III), ferric	Fe^{3+}
Lead(II), plumbous	Pb^{2+}
Lead(IV), plumbic	Pb^{4+}
Lithium	Li^+
Magnesium	Mg^{2+}
Manganese(II), manganous	Mn^{2+}
Manganese(IV)	Mn^{4+}
Mercury(I)*, mercurous	Hg_2^{2+}
Mercury(II), mercuric	Hg^{2+}
Potassium	K^+
Silver	Ag^+
Sodium	Na^+
Tin(II)*, stannous	Sn^{2+}
Tin(IV), stannic	Sn^{4+}
Zinc	Zn^{2+}

* Aqueous solutions are readily oxidized by air.

** Not stable in aqueous solutions.

Negative ions (anions)	
Bromide	Br^-
Carbonate	CO_3^{2-}
Chlorate	ClO_3^-
Chloride	Cl^-
Chlorite	ClO_2^-
Chromate	CrO_4^{2-}
Cyanide	CN^-
Dichromate	$Cr_2O_7^{2-}$
Dihydrogen phosphate	$H_2PO_4^-$
Ethanoate, Acetate	CH_3COO^-
Fluoride	F^-
Hydrogen carbonate, bicarbonate	HCO_3^-
Hydrogen oxalate, binoxalate	$HC_2O_4^-$
Hydrogen sulphate, bisulphate	HSO_4^-
Hydrogen sulphide, bisulphide	HS^-
Hydrogen sulphite, bisulphite	HSO_3^-
Hydroxide	OH^-
Hypochlorite	ClO^-
Iodide	I^-
Monohydrogen phosphate	HPO_4^{2-}
Nitrate	NO_3^-
Nitrite	NO_2^-
Oxalate	$C_2O_4^{2-}$
Oxide**	O^{2-}
Perchlorate	ClO_4^-
Permanganate	MnO_4^-
Phosphate	PO_4^{3-}
Sulphate	SO_4^{2-}
Sulphide	S^{2-}
Sulphite	SO_3^{2-}
Thiocyanate	SCN^-

SOLUBILITY OF COMMON COMPOUNDS IN WATER

The term soluble here means > $0.1 \ \text{mol/L}$ at 25°C.

NEGATIVE IONS (Anions)	**POSITIVE IONS (Cations)**	**SOLUBILITY OF COMPOUNDS**
All	Alkali ions: Li^+, Na^+, K^+, Rb^+, Cs^+, Fr^+	Soluble
All	Hydrogen ion, H^+	Soluble
All	Ammonium ion, NH_4^+	Soluble
Nitrate, NO_3^-	All	Soluble
Chloride, Cl^- or Bromide, Br^- or Iodide, I^-	All others	Soluble
	Ag^+, Pb^{2+}, Cu^+	Low Solubility
Sulphate, SO_4^{2-}	All others	Soluble
	Ag^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}	Low Solubility
Sulphide, S^{2-}	Alkali ions, H^+, NH_4^+, Be^{2+} Mg^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}	Soluble
	All others	Low Solubility
Hydroxide, OH^-	Alkali ions, H^+, NH_4^+, Sr^{2+}	Soluble
	All others	Low Solubility
Phosphate, PO_4^{3-} or Carbonate, CO_3^{2-} or Sulphite, SO_3^{2-}	Alkali ions, H^+, NH_4^+	Soluble
	All others	Low Solubility

SOLUBILITY PRODUCT CONSTANTS AT 25˚C

Name	**Formula**	**K_{sp}**
barium carbonate	$BaCO_3$	2.6×10^{-9}
barium chromate	$BaCrO_4$	1.2×10^{-10}
barium sulphate	$BaSO_4$	1.1×10^{-10}
calcium carbonate	$CaCO_3$	5.0×10^{-9}
calcium oxalate	CaC_2O_4	2.3×10^{-9}
calcium sulphate	$CaSO_4$	7.1×10^{-5}
copper(I) iodide	CuI	1.3×10^{-12}
copper(II) iodate	$Cu(IO_3)_2$	6.9×10^{-8}
copper(II) sulphide	CuS	6.0×10^{-37}
iron(II) hydroxide	$Fe(OH)_2$	4.9×10^{-17}
iron(II) sulphide	FeS	6.0×10^{-19}
iron(III) hydroxide	$Fe(OH)_3$	2.6×10^{-39}
lead(II) bromide	$PbBr_2$	6.6×10^{-6}
lead(II) chloride	$PbCl_2$	1.2×10^{-5}
lead(II) iodate	$Pb(IO_3)_2$	3.7×10^{-13}
lead(II) iodide	PbI_2	8.5×10^{-9}
lead(II) sulphate	$PbSO_4$	1.8×10^{-8}
magnesium carbonate	$MgCO_3$	6.8×10^{-6}
magnesium hydroxide	$Mg(OH)_2$	5.6×10^{-12}
silver bromate	$AgBrO_3$	5.3×10^{-5}
silver bromide	$AgBr$	5.4×10^{-13}
silver carbonate	Ag_2CO_3	8.5×10^{-12}
silver chloride	$AgCl$	1.8×10^{-10}
silver chromate	Ag_2CrO_4	1.1×10^{-12}
silver iodate	$AgIO_3$	3.2×10^{-8}
silver iodide	AgI	8.5×10^{-17}
strontium carbonate	$SrCO_3$	5.6×10^{-10}
strontium fluoride	SrF_2	4.3×10^{-9}
strontium sulphate	$SrSO_4$	3.4×10^{-7}
zinc sulphide	ZnS	2.0×10^{-25}

RELATIVE STRENGTHS OF BRÖNSTED-LOWRY ACIDS AND BASES

in aqueous solution at room temperature

Strength of Acid	Name of Acid	Acid		Base	K_a	Strength of Base
Strong ↑	Perchloric	$HClO_4$	$\rightarrow$	$H^+ + ClO_4^-$	very large	Weak ↓
	Hydriodic	HI	$\rightarrow$	$H^+ + I^-$	very large	
	Hydrobromic	HBr	$\rightarrow$	$H^+ + Br^-$	very large	
	Hydrochloric	HCl	$\rightarrow$	$H^+ + Cl^-$	very large	
	Nitric	HNO_3	$\rightarrow$	$H^+ + NO_3^-$	very large	
	Sulphuric	H_2SO_4	$\rightarrow$	$H^+ + HSO_4^-$	very large	
	Hydronium Ion	H_3O^+	$\rightleftarrows$	$H^+ + H_2O$	1.0	
	Iodic	HIO_3	$\rightleftarrows$	$H^+ + IO_3^-$	1.7×10^{-1}	
	Oxalic	$H_2C_2O_4$	$\rightleftarrows$	$H^+ + HC_2O_4^-$	5.9×10^{-2}	
	Sulphurous $(SO_2 + H_2O)$	H_2SO_3	$\rightleftarrows$	$H^+ + HSO_3^-$	1.5×10^{-2}	
	Hydrogen sulphate ion	HSO_4^-	$\rightleftarrows$	$H^+ + SO_4^{2-}$	1.2×10^{-2}	
	Phosphoric	H_3PO_4	$\rightleftarrows$	$H^+ + H_2PO_4^-$	7.5×10^{-3}	
	Hexaaquoiron ion, iron(III) ion	$Fe(H_2O)_6^{3+}$	$\rightleftarrows$	$H^+ + Fe(H_2O)_5(OH)^{2+}$	6.0×10^{-3}	
	Citric	$H_3C_6H_5O_7$	$\rightleftarrows$	$H^+ + H_2C_6H_5O_7^-$	7.1×10^{-4}	
	Nitrous	HNO_2	$\rightleftarrows$	$H^+ + NO_2^-$	4.6×10^{-4}	
	Hydrofluoric	HF	$\rightleftarrows$	$H^+ + F^-$	3.5×10^{-4}	
	Methanoic, formic	$HCOOH$	$\rightleftarrows$	$H^+ + HCOO^-$	1.8×10^{-4}	
	Hexaaquochromium ion, chromium(III) ion	$Cr(H_2O)_6^{3+}$	$\rightleftarrows$	$H^+ + Cr(H_2O)_5(OH)^{2+}$	1.5×10^{-4}	
	Benzoic	C_6H_5COOH	$\rightleftarrows$	$H^+ + C_6H_5COO^-$	6.5×10^{-5}	
	Hydrogen oxalate ion	$HC_2O_4^-$	$\rightleftarrows$	$H^+ + C_2O_4^{2-}$	6.4×10^{-5}	
	Ethanoic, acetic	CH_3COOH	$\rightleftarrows$	$H^+ + CH_3COO^-$	1.8×10^{-5}	
	Dihydrogen citrate ion	$H_2C_6H_5O_7^-$	$\rightleftarrows$	$H^+ + HC_6H_5O_7^{2-}$	1.7×10^{-5}	
	Hexaaquoaluminum ion, aluminum ion	$Al(H_2O)_6^{3+}$	$\rightleftarrows$	$H^+ + Al(H_2O)_5(OH)^{2+}$	1.4×10^{-5}	
	Carbonic $(CO_2 + H_2O)$	H_2CO_3	$\rightleftarrows$	$H^+ + HCO_3^-$	4.3×10^{-7}	
	Monohydrogen citrate ion	$HC_6H_5O_7^{2-}$	$\rightleftarrows$	$H^+ + C_6H_5O_7^{3-}$	4.1×10^{-7}	
	Hydrogen sulphite ion	HSO_3^-	$\rightleftarrows$	$H^+ + SO_3^{2-}$	1.0×10^{-7}	
	Hydrogen sulphide	H_2S	$\rightleftarrows$	$H^+ + HS^-$	9.1×10^{-8}	
	Dihydrogen phosphate ion	$H_2PO_4^-$	$\rightleftarrows$	$H^+ + HPO_4^{2-}$	6.2×10^{-8}	
	Boric	H_3BO_3	$\rightleftarrows$	$H^+ + H_2BO_3^-$	7.3×10^{-10}	
	Ammonium ion	NH_4^+	$\rightleftarrows$	$H^+ + NH_3$	5.6×10^{-10}	
	Hydrocyanic	HCN	$\rightleftarrows$	$H^+ + CN^-$	4.9×10^{-10}	
	Phenol	C_6H_5OH	$\rightleftarrows$	$H^+ + C_6H_5O^-$	1.3×10^{-10}	
	Hydrogen carbonate ion	HCO_3^-	$\rightleftarrows$	$H^+ + CO_3^{2-}$	5.6×10^{-11}	
	Hydrogen peroxide	H_2O_2	$\rightleftarrows$	$H^+ + HO_2^-$	2.4×10^{-12}	
	Monohydrogen phosphate ion	HPO_4^{2-}	$\rightleftarrows$	$H^+ + PO_4^{3-}$	2.2×10^{-13}	
	Water	H_2O	$\rightleftarrows$	$H^+ + OH^-$	1.0×10^{-14}	
	Hydroxide ion	OH^-	$\leftarrow$	$H^+ + O^{2-}$	very small	
	Ammonia	NH_3	$\leftarrow$	$H^+ + NH_2^-$	very small	
Weak						Strong

ACID-BASE INDICATORS

INDICATOR	pH RANGE IN WHICH COLOUR CHANGE OCCURS	COLOUR CHANGE AS pH INCREASES
Methyl violet	0.0 – 1.6	yellow to blue
Thymol blue	1.2 – 2.8	red to yellow
Orange IV	1.4 – 2.8	red to yellow
Methyl orange	3.2 – 4.4	red to yellow
Bromcresol green	3.8 – 5.4	yellow to blue
Methyl red	4.8 – 6.0	red to yellow
Chlorophenol red	5.2 – 6.8	yellow to red
Bromthymol blue	6.0 – 7.6	yellow to blue
Phenol red	6.6 – 8.0	yellow to red
Neutral red	6.8 – 8.0	red to amber
Thymol blue	8.0 – 9.6	yellow to blue
Phenolphthalein	8.2 – 10.0	colourless to pink
Thymolphthalein	9.4 – 10.6	colourless to blue
Alizarin yellow	10.1 – 12.0	yellow to red
Indigo carmine	11.4 – 13.0	blue to yellow

STANDARD REDUCTION POTENTIALS OF HALF-CELLS

Ionic Concentrations are at 1*M* in Water at 25° C

STRENGTH OF OXIDIZING AGENT	OXIDIZING AGENTS		REDUCING AGENTS	E°(VOLTS)	STRENGTH OF REDUCING AGENT
strong	$F_{2(g)} + 2e^-$	⇄	$2F^-$	+2.87	weak
	$S_2O_8^{2-} + 2e^-$	⇄	$2SO_4^{2-}$	+2.01	
	$H_2O_2 + 2H^+ + 2e^-$	⇄	$2H_2O$	+1.78	
	$MnO_4^- + 8H^+ + 5e^-$	⇄	$Mn^{2+} + 4H_2O$	+1.51	
	$Au^{3+} + 3e^-$	⇄	$Au_{(s)}$	+1.50	
	$BrO_3^- + 6H^+ + 5e^-$	⇄	$\frac{1}{2}Br_{2(l)} + 3H_2O$	+1.48	
	$ClO_4^- + 8H^+ + 8e^-$	⇄	$Cl^- + 4H_2O$	+1.39	
	$Cl_{2(g)} + 2e^-$	⇄	$2Cl^-$	+1.36	Overpotential Effect
	$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇄	$2Cr^{3+} + 7H_2O$	+1.23	
	$\frac{1}{2}O_{2(g)} + 2H^+ + 2e^-$	⇄	H_2O	+1.23	
	$MnO_{2(s)} + 4H^+ + 2e^-$	⇄	$Mn^{2+} + 2H_2O$	+1.22	
	$IO_3^- + 6H^+ + 5e^-$	⇄	$\frac{1}{2}I_{2(s)} + 3H_2O$	+1.20	
	$Br_{2(l)} + 2e^-$	⇄	$2Br^-$	+1.09	
	$AuCl_4^- + 3e^-$	⇄	$Au_{(s)} + 4Cl^-$	+1.00	
	$NO_3^- + 4H^+ + 3e^-$	⇄	$NO_{(g)} + 2H_2O$	+0.96	
	$Hg^{2+} + 2e^-$	⇄	$Hg_{(l)}$	+0.85	
	$\frac{1}{2}O_{2(g)} + 2H^+(10^{-7}M) + 2e^-$	⇄	H_2O	+0.82	
	$2NO_3^- + 4H^+ + 2e^-$	⇄	$N_2O_4 + 2H_2O$	+0.80	
	$Ag^+ + e^-$	⇄	$Ag_{(s)}$	+0.80	
	$\frac{1}{2}Hg_2^{2+} + e^-$	⇄	$Hg_{(l)}$	+0.80	
	$Fe^{3+} + e^-$	⇄	Fe^{2+}	+0.77	
	$O_{2(g)} + 2H^+ + 2e^-$	⇄	H_2O_2	+0.70	
	$MnO_4^- + 2H_2O + 3e^-$	⇄	$MnO_{2(s)} + 4OH^-$	+0.60	
	$I_{2(s)} + 2e^-$	⇄	$2I^-$	+0.54	
	$Cu^+ + e^-$	⇄	$Cu_{(s)}$	+0.52	
	$H_2SO_3 + 4H^+ + 4e^-$	⇄	$S_{(s)} + 3H_2O$	+0.45	
	$Cu^{2+} + 2e^-$	⇄	$Cu_{(s)}$	+0.34	
	$SO_4^{2-} + 4H^+ + 2e^-$	⇄	$H_2SO_3 + H_2O$	+0.17	
	$Cu^{2+} + e^-$	⇄	Cu^+	+0.15	
	$Sn^{4+} + 2e^-$	⇄	Sn^{2+}	+0.15	
	$S_{(s)} + 2H^+ + 2e^-$	⇄	$H_2S_{(g)}$	+0.14	
	$2H^+ + 2e^-$	⇄	$H_{2(g)}$	+0.00	
	$Pb^{2+} + 2e^-$	⇄	$Pb_{(s)}$	−0.13	
	$Sn^{2+} + 2e^-$	⇄	$Sn_{(s)}$	−0.14	
	$Ni^{2+} + 2e^-$	⇄	$Ni_{(s)}$	−0.26	
	$H_3PO_4 + 2H^+ + 2e^-$	⇄	$H_3PO_3 + H_2O$	−0.28	
	$Co^{2+} + 2e^-$	⇄	$Co_{(s)}$	−0.28	
	$Se_{(s)} + 2H^+ + 2e^-$	⇄	H_2Se	−0.40	
	$Cr^{3+} + e^-$	⇄	Cr^{2+}	−0.41	
Overpotential Effect	$2H_2O + 2e^-$	⇄	$H_2 + 2OH^-(10^{-7}M)$	−0.41	
	$Fe^{2+} + 2e^-$	⇄	$Fe_{(s)}$	−0.45	
	$Ag_2S_{(s)} + 2e^-$	⇄	$2Ag_{(s)} + S^{2-}$	−0.69	
	$Cr^{3+} + 3e^-$	⇄	$Cr_{(s)}$	−0.74	
	$Zn^{2+} + 2e^-$	⇄	$Zn_{(s)}$	−0.76	
	$Te_{(s)} + 2H^+ + 2e^-$	⇄	H_2Te	−0.79	
	$2H_2O + 2e^-$	⇄	$H_{2(g)} + 2OH^-$	−0.83	
	$Mn^{2+} + 2e^-$	⇄	$Mn_{(s)}$	−1.19	
	$Al^{3+} + 3e^-$	⇄	$Al_{(s)}$	−1.66	
	$Mg^{2+} + 2e^-$	⇄	$Mg_{(s)}$	−2.37	
	$Na^+ + e^-$	⇄	$Na_{(s)}$	−2.71	
	$Ca^{2+} + 2e^-$	⇄	$Ca_{(s)}$	−2.87	
	$Sr^{2+} + 2e^-$	⇄	$Sr_{(s)}$	−2.89	
	$Ba^{2+} + 2e^-$	⇄	$Ba_{(s)}$	−2.91	
	$K^+ + e^-$	⇄	$K_{(s)}$	−2.93	
	$Rb^+ + e^-$	⇄	$Rb_{(s)}$	−2.98	
	$Cs^+ + e^-$	⇄	$Cs_{(s)}$	−3.03	
weak	$Li^+ + e^-$	⇄	$Li_{(s)}$	−3.04	strong