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Chemistry 12
JUNE 2001

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.

Question 1:

1. .

(4)

Question 7:

7. .

(5)

Question 2:

2. .

(2)

Question 8:

8. .

(4)

Question 3:

3. .

(4)

Question 9:

9. .

(2)

Question 4:

4. .

(4)

Question 10:

10. .

(3)

Question 5:

5. .

(4)

Question 11:

11. .

(2)

Question 6:

6. .

(2)

Question 12:

12. .

(4)

CHEMISTRY 12

JUNE 2001

COURSE CODE = CH

GENERAL INSTRUCTIONS

1. Aside from an approved calculator, electronic devices, including dictionaries and pagers, are **not** permitted in the examination room.
2. 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.
3. For each of the written-response questions, write your answer in the space provided in this booklet.
4. Ensure that you use language and content appropriate to the purpose and audience of this examination. Failure to comply may result in your paper being awarded a zero.
5. This examination is designed to be completed in **two hours**. *Students may, however, take up to 30 minutes of additional time to finish.*

CHEMISTRY 12 PROVINCIAL EXAMINATION

	Value	Suggested Time
1. This examination consists of two parts:		
PART A: 48 multiple-choice questions	60	70
PART B: 12 written-response questions	40	50
Total:	100 marks	120 minutes

2. The following tables can be found in the separate **Data Booklet**.

- Periodic Table of the Elements
- Atomic Masses of the Elements
- Names, Formulae, and Charges of Some Common Ions
- Solubility of Common Compounds in Water
- Solubility Product Constants at 25°C
- Relative Strengths of Brønsted-Lowry Acids and Bases
- Acid-Base Indicators
- Standard Reduction Potentials of Half-cells

No other reference materials or tables are allowed.

3. **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 devices to support calculators such as manuals, printed or electronic cards, printers, memory expansion chips or cards, or external keyboards. Students may have more than one calculator available during the examination. Calculators may not be shared and 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.

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PART A: MULTIPLE CHOICE

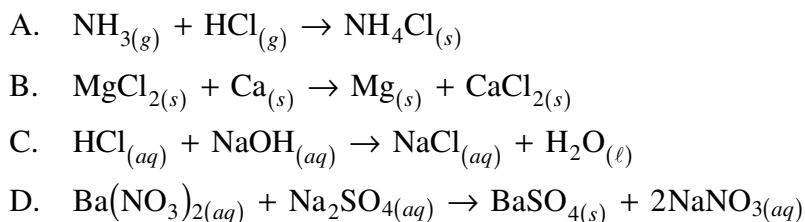
Value: 60 marks

Suggested Time: 70 minutes

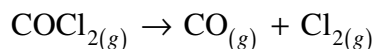
INSTRUCTIONS: For each question, select the **best** answer and record your choice on the Response Form provided. Using an HB pencil, completely fill in the circle that has the letter corresponding to your answer.

Selected multiple-choice questions are worth 2 marks.

1. Which of the following reactions is slowest at room temperature? (1 mark)



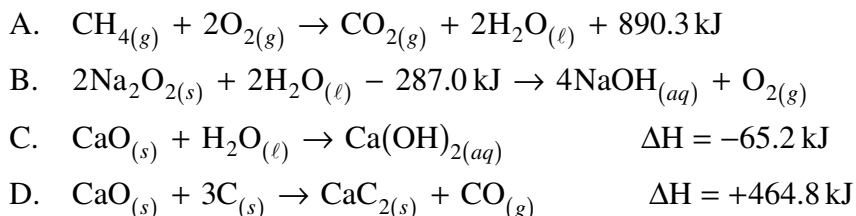
2. Consider the following reaction: (1 mark)



Which of the following could be used to determine reaction rate in a closed system?

- A. a decrease in gas pressure
B. an increase in gas pressure
C. a decrease in the mass of the system
D. an increase in the mass of the system
3. *Activation energy* is defined as the (1 mark)
- A. ΔH .
B. average kinetic energy.
C. energy of a particle's motion.
D. minimum energy needed for a successful collision.

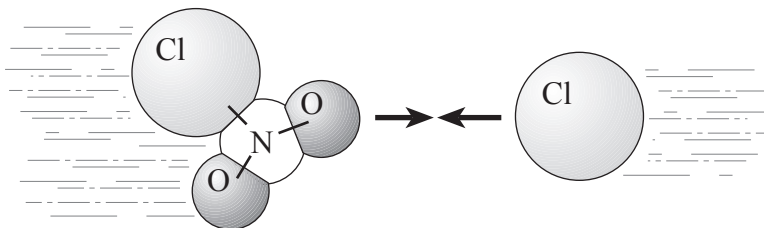
4. Which of the following reactions is endothermic? (1 mark)



OVER

5. The following diagram shows reactant molecules approaching one another:

(2 marks)



What is happening to the kinetic energy and the potential energy?

	Kinetic Energy	Potential Energy
A.	decreasing	decreasing
B.	decreasing	increasing
C.	increasing	increasing
D.	increasing	decreasing

6. A proposed mechanism for a reaction is:

(1 mark)

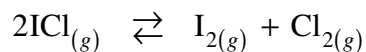
Step 1	$\text{H}_3\text{O}^+ + \text{I}^- \rightarrow \text{HI} + \text{H}_2\text{O}$
Step 2	$\text{H}_2\text{O}_2 + \text{HI} \rightarrow \text{H}_2\text{O} + \text{HOI}$
Step 3	$\text{HOI} + \text{H}_3\text{O}^+ + \text{I}^- \rightarrow 2\text{H}_2\text{O} + \text{I}_2$
Step 4	$\text{I}_2 + \text{I}^- \rightarrow \text{I}_3^-$

In the above mechanism, which of the following is true for the overall reaction?

- A. HI is a catalyst
- B. H_3O^+ is a product
- C. H_2O_2 is a reactant
- D. H_2O is an intermediate

7. Consider the following reaction:

(2 marks)



A closed container is initially filled with $\text{ICl}_{(g)}$. What are the changes in the rate of the forward reaction and $[\text{I}_2]$, as the system approaches equilibrium?

	Rate of forward reaction	$[\text{I}_2]$
A.	decreases	increases
B.	decreases	decreases
C.	increases	increases
D.	increases	decreases

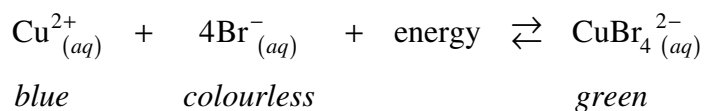
8. The entropy of a system is a term used to describe

(1 mark)

- A. randomness.
- B. heat content.
- C. average kinetic energy.
- D. stored chemical energy.

9. Consider the following equilibrium:

(1 mark)



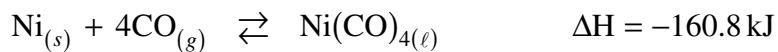
Which of the following will cause this equilibrium to change from blue to green?

- A. adding $\text{NaBr}_{(s)}$
- B. adding $\text{NaNO}_{3(s)}$
- C. adding a catalyst
- D. decreasing the temperature

OVER

10. Consider the following equilibrium:

(1 mark)

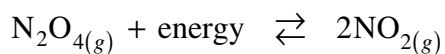


Which of the following will cause this equilibrium to shift to the left?

- A. add some CO
- B. decrease the volume
- C. remove some $\text{Ni}(\text{CO})_4$
- D. increase the temperature

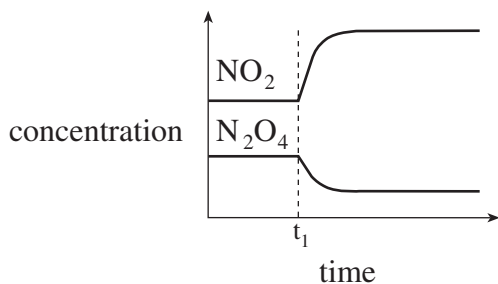
11. Consider the following equilibrium:

(1 mark)

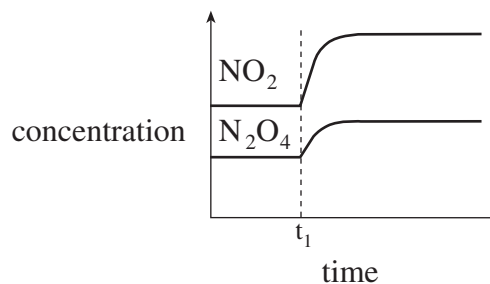


Which of the following shows the relationship between concentration and time as a result of adding a catalyst at time = t_1 ?

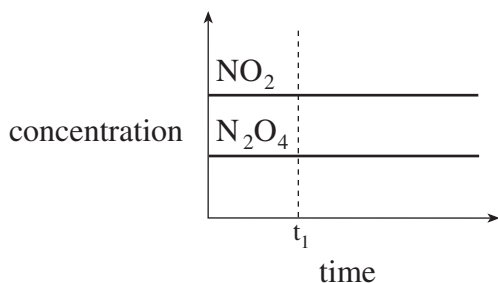
A.



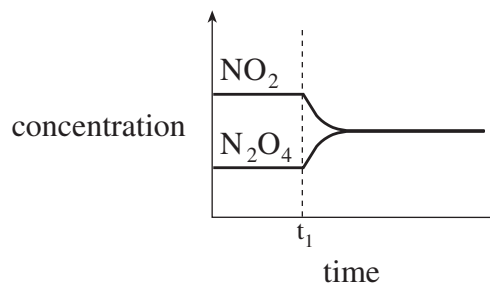
B.



C.

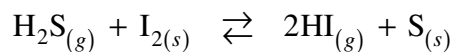


D.



12. Consider the following equilibrium:

(1 mark)

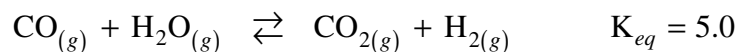


What is the equilibrium expression for this reaction?

- A. $K_{eq} = \frac{[\text{HI}]^2}{[\text{H}_2\text{S}]}$
- B. $K_{eq} = \frac{[\text{H}_2\text{S}]}{[\text{HI}]^2}$
- C. $K_{eq} = \frac{[\text{HI}]^2[\text{S}]}{[\text{H}_2\text{S}][\text{I}_2]}$
- D. $K_{eq} = \frac{[\text{H}_2\text{S}][\text{I}_2]}{[\text{HI}]^2[\text{S}]}$

13. Consider the following equilibrium:

(1 mark)



At equilibrium, the $[\text{CO}] = 0.20 \text{ mol/L}$, $[\text{H}_2\text{O}] = 0.30 \text{ mol/L}$, and $[\text{H}_2] = 0.90 \text{ mol/L}$.
Calculate the equilibrium $[\text{CO}_2]$.

- A. 0.013 mol/L
- B. 0.066 mol/L
- C. 0.33 mol/L
- D. 1.0 mol/L

14. Consider the following:

(2 marks)



In a reaction container the initial concentrations are:

$$[\text{CO}_2] = 0.50 \text{ mol/L}, [\text{CF}_4] = 0.50 \text{ mol/L}, [\text{COF}_2] = 0.30 \text{ mol/L}$$

To reach equilibrium, the reaction will proceed

- A. left since Trial $K_{eq} < K_{eq}$
- B. left since Trial $K_{eq} > K_{eq}$
- C. right since Trial $K_{eq} < K_{eq}$
- D. right since Trial $K_{eq} > K_{eq}$

15. Consider the following equilibrium:

(1 mark)



Adding which of the following will cause more solid BaSO_4 to form?

- A. $\text{CaCl}_{2(s)}$
- B. $\text{K}_2\text{CO}_{3(s)}$
- C. $\text{Na}_2\text{SO}_{4(s)}$
- D. $\text{Mg}(\text{NO}_3)_{2(s)}$

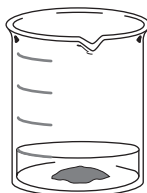
16. Which of the following could **not** be used to represent solubility?

(1 mark)

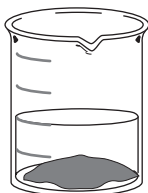
- A. g/mL
- B. mL/L
- C. mol/L
- D. g/min

17. The following three beakers each contain different volumes of a saturated solution of PbI_2 and different masses of solid PbI_2 :

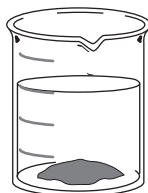
(2 marks)



Beaker I



Beaker II



Beaker III

What is the relationship for the $[\text{Pb}^{2+}]$ in the solution in the three beakers?

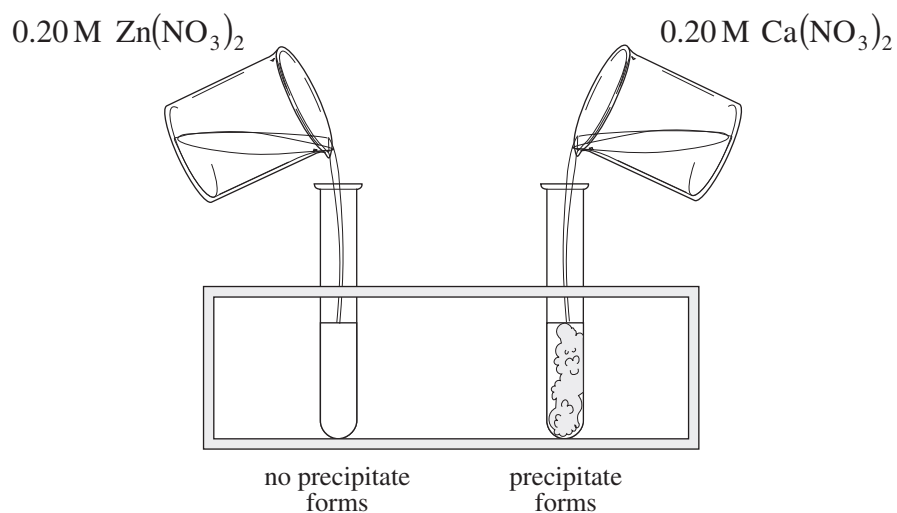
- A. $\text{I} = \text{II} = \text{III}$
- B. $\text{I} > \text{II} > \text{III}$
- C. $\text{II} > \text{III} > \text{I}$
- D. $\text{III} > \text{II} > \text{I}$

18. The equation that describes the solubility equilibrium of Ag_2CrO_4 is

(1 mark)

- A. $\text{Ag}_2\text{CrO}_{4(s)} \rightleftharpoons \text{Ag}_2^{2+}_{(aq)} + \text{CrO}_4^{2-}_{(aq)}$
- B. $\text{Ag}_2\text{CrO}_{4(s)} \rightleftharpoons 2\text{Ag}^+_{(aq)} + \text{CrO}_4^{2-}_{(aq)}$
- C. $\text{Ag}_2\text{CrO}_{4(s)} \rightleftharpoons 2\text{Ag}_{(s)} + \text{Cr}_{(s)} + 2\text{O}_{2(g)}$
- D. $\text{Ag}_2\text{CrO}_{4(s)} \rightleftharpoons 2\text{Ag}^+_{(aq)} + \text{Cr}^{6+}_{(aq)} + 4\text{O}^{2-}_{(aq)}$

19. When 10.0 mL of 0.20 M $\text{Zn}(\text{NO}_3)_2$ is added to a 10.0 mL sample of 0.20 M unknown solution, no precipitate forms. When the same volume of 0.20 M $\text{Ca}(\text{NO}_3)_2$ is added to a separate 10.0 mL sample of the unknown solution, a precipitate does form. **(2 marks)**



The identity of the unknown solution could be

- A. NaCl
 - B. Na_2S
 - C. Na_2SO_4
 - D. Na_2CO_3
20. The solubility of PbS is 1.8×10^{-14} M. The value of K_{sp} is **(1 mark)**
- A. 3.2×10^{-28}
 - B. 1.8×10^{-14}
 - C. 3.6×10^{-14}
 - D. 1.3×10^{-7}

21. A hydronium ion has the formula (1 mark)
- A. H_2^+
 - B. OH^-
 - C. H_2O^+
 - D. H_3O^+
22. The conjugate acid of $\text{C}_6\text{H}_5\text{NH}_2$ is (1 mark)
- A. $\text{C}_6\text{H}_5\text{NH}^-$
 - B. $\text{C}_6\text{H}_5\text{NH}_3$
 - C. $\text{C}_6\text{H}_5\text{NH}_2^+$
 - D. $\text{C}_6\text{H}_5\text{NH}_3^+$
23. Which of the following is a property of 1.0 M HCl but not a property of 1.0 M CH_3COOH ? (1 mark)
- A. turns litmus red
 - B. ionizes completely
 - C. has a pH less than 7.0
 - D. produces H_3O^+ in solution
24. In a 1.0 M HF solution, the concentration of HF, F^- , and OH^- , from highest to lowest is (2 marks)
- A. $[\text{HF}] > [\text{F}^-] > [\text{OH}^-]$
 - B. $[\text{F}^-] > [\text{HF}] > [\text{OH}^-]$
 - C. $[\text{OH}^-] > [\text{HF}] > [\text{F}^-]$
 - D. $[\text{OH}^-] > [\text{F}^-] > [\text{HF}]$

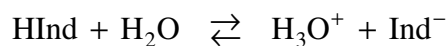
25. In which of the following reactions is water behaving as a Brønsted-Lowry acid? **(1 mark)**
- A. $2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2$
 - B. $\text{HCl} + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{Cl}^-$
 - C. $\text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{NH}_4^+ + \text{OH}^-$
 - D. $\text{NH}_4^+ + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{NH}_3$
26. What is the $[\text{OH}^-]$ of a solution with $[\text{H}_3\text{O}^+] = 9.3 \times 10^{-2} \text{ M}$? **(1 mark)**
- A. $9.3 \times 10^{-16} \text{ M}$
 - B. $8.6 \times 10^{-13} \text{ M}$
 - C. $1.1 \times 10^{-13} \text{ M}$
 - D. $9.3 \times 10^{-2} \text{ M}$
27. The pH of 0.10 M HNO_3 is **(1 mark)**
- A. 0.79
 - B. 1.00
 - C. 1.26
 - D. 13.00
28. What is the pOH of a solution made by adding 50.0 mL of 0.50 M NaOH to 250.0 mL of water? **(2 marks)**
- A. 0.30
 - B. 1.00
 - C. 1.08
 - D. 12.92
29. Which of the following 1.0 M solutions will have the lowest pH? **(1 mark)**
- A. HCl
 - B. HCN
 - C. H_3PO_4
 - D. $\text{H}_2\text{C}_2\text{O}_4$

30. The value of K_b for HTe^- is 4.8×10^{-7} . The value of K_a for H_2Te is **(1 mark)**
- A. 4.8×10^{-21}
 - B. 2.3×10^{-13}
 - C. 2.1×10^{-8}
 - D. 4.8×10^{-7}

31. In an aqueous solution of NaCl , the pH is **(1 mark)**
- A. less than 7 and the solution is acidic.
 - B. equal to 7 and the solution is neutral.
 - C. greater than 7 and the solution is basic.
 - D. greater than 7 and the solution is acidic.

Use the following equation for questions 32 and 33.

Consider the following equation for the indicator methyl red, HInd .



32. At $\text{pH} = 4.0$, methyl red solution will be **(2 marks)**
- A. red and $[\text{HInd}] > [\text{Ind}^-]$
 - B. red and $[\text{HInd}] < [\text{Ind}^-]$
 - C. yellow and $[\text{HInd}] > [\text{Ind}^-]$
 - D. yellow and $[\text{HInd}] < [\text{Ind}^-]$
33. Methyl red is orange in a 0.10 M solution of an acid. The acid could be **(1 mark)**
- A. HI
 - B. HCl
 - C. HCN
 - D. H_2SO_4

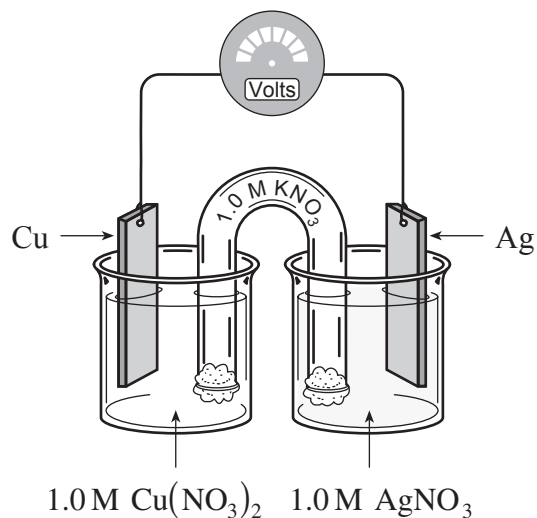
OVER

34. How many moles of KOH are necessary to completely neutralize 42.0 mL of 3.00 M HCl? **(1 mark)**
- A. 0.0630 moles
 - B. 0.126 moles
 - C. 0.252 moles
 - D. 3.00 moles
35. At the equivalence point, the titration of HCl with NH₃ will form a solution which is **(2 marks)**
- A. basic with pH > 7.
 - B. acidic with pH < 7.
 - C. acidic with pH > 7.
 - D. neutral with pH = 7.
36. Which of the following could be added to an equal number of moles of NaCH₃COO to prepare a buffer solution? **(1 mark)**
- A. HCl
 - B. HNO₃
 - C. NaOH
 - D. CH₃COOH
37. Which of the following equations describes the reaction that occurs when MgO is added to water? **(1 mark)**
- A. $\text{MgO} + \text{H}_2\text{O} \rightarrow \text{Mg}(\text{OH})_2$
 - B. $\text{MgO} + \text{H}_2\text{O} \rightarrow \text{MgO}_2 + \text{H}_2$
 - C. $\text{MgO} + \text{H}_2\text{O} \rightarrow \text{MgH}_2 + \text{O}_2$
 - D. $2\text{MgO} + 2\text{H}_2\text{O} \rightarrow 2\text{MgOH} + \text{H}_2 + \text{O}_2$
38. Which of the following represents a redox reaction? **(1 mark)**
- A. $\text{H}_2 + \text{I}_2 \rightarrow 2\text{HI}$
 - B. $\text{HCl} + \text{NH}_3 \rightarrow \text{NH}_4\text{Cl}$
 - C. $\text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{H}_2\text{CO}_3$
 - D. $2\text{NaI} + \text{Pb}(\text{NO}_3)_2 \rightarrow \text{PbI}_2 + 2\text{NaNO}_3$

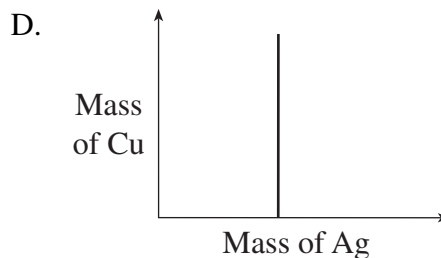
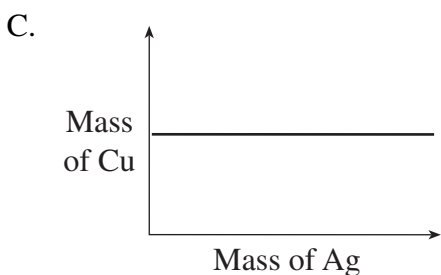
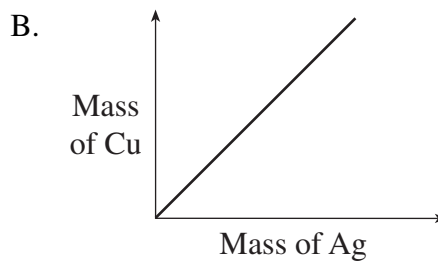
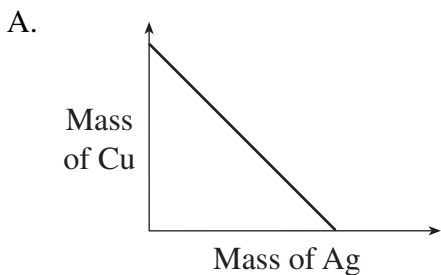
39. In an experiment, Ag^+ reacts spontaneously with Ru but not with Pd.
The relative strength of the metals from strongest to weakest reducing agent is **(2 marks)**
- A. $\text{Ag} > \text{Ru} > \text{Pd}$
 - B. $\text{Pd} > \text{Ag} > \text{Ru}$
 - C. $\text{Ru} > \text{Ag} > \text{Pd}$
 - D. $\text{Ru} > \text{Pd} > \text{Ag}$
40. A piece of Ag does not react spontaneously with 1.0 M Ti^{2+} because **(1 mark)**
- A. Ag^+ is a weaker reducing agent than Ti^{2+}
 - B. Ag^+ is a weaker oxidizing agent than Ti^{2+}
 - C. Ag^+ is a stronger reducing agent than Ti^{2+}
 - D. Ag^+ is a stronger oxidizing agent than Ti^{2+}
41. Which of the following will react spontaneously with Ag_2S at standard conditions? **(1 mark)**
- A. Al
 - B. Au
 - C. Co
 - D. Pb
42. When a piece of Cu is placed in 1.0 M HNO_3 , **(1 mark)**
- A. the $[\text{H}^+]$ increases.
 - B. the $[\text{Cu}^{2+}]$ decreases.
 - C. the $[\text{NO}_3^-]$ decreases.
 - D. no change occurs.
43. When MnO_2 changes to Mn_2O_3 in an alkaline battery, manganese atoms **(2 marks)**
- A. lose electrons and are reduced.
 - B. gain electrons and are reduced.
 - C. lose electrons and are oxidized.
 - D. gain electrons and are oxidized.

OVER

Use the following cell to answer questions 44 and 45.



44. Which of the following diagrams represents the relationship between the mass of the Cu electrode and the mass of the Ag electrode as the cell is in operation? **(1 mark)**



45. The E° for the above cell is **(1 mark)**

- A. -1.14 Volts
- B. -0.46 Volts
- C. $+0.46$ Volts
- D. $+1.14$ Volts

46. The value of E° for a cell can be used to determine (1 mark)
- A. rate.
 - B. spontaneity.
 - C. temperature.
 - D. activation energy.
47. How is the formation of rust on an iron can inhibited by a tin coating? (1 mark)
- A. The tin is a sacrificial anode.
 - B. The tin cathodically protects the iron.
 - C. The tin is a weaker reducing agent than iron.
 - D. The tin keeps the oxygen away from the iron.
48. The electrolysis of 1.0 M CuF_2 using inert electrodes will produce (2 marks)
- A. copper and oxygen.
 - B. copper and fluorine.
 - C. hydrogen and oxygen.
 - D. hydrogen and fluorine.

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

OVER

PART B: WRITTEN RESPONSE

Value: 40 marks

Suggested Time: 50 minutes

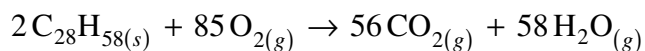
INSTRUCTIONS: You will be expected to communicate your knowledge and understanding of chemical principles in a clear and logical manner.

Your steps and assumptions leading to a solution must be written in the spaces below the questions.

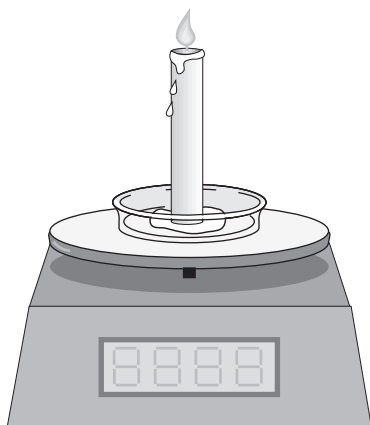
Answers must include units where appropriate and be given to the correct number of significant figures.

For questions involving calculation, full marks will NOT be given for providing only an answer.

1. The mass of a burning candle is monitored to determine the rate of combustion of paraffin. An accepted reaction for the combustion of paraffin is:



The following data is observed:



Time (min)	Mass of Candle (g)
0.0	25.6
6.0	25.1
12.0	24.5
18.0	23.9
24.0	23.4
30.0	22.8

a) Calculate the average rate of consumption of paraffin in g/min for the time interval 12.0 to 24.0 minutes.

(2 marks)

b) Calculate the rate of CO₂ production in mol/min for the time interval 12.0 to 24.0 minutes.

(2 marks)

2. Write **four** statements that apply to all chemical equilibrium systems.

(2 marks)

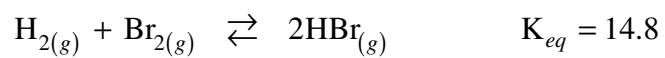
i) _____

ii) _____

iii) _____

iv) _____

3. Consider the following equilibrium system:



A closed container was initially filled with equal moles of H_2 and Br_2 .

When equilibrium is reached, the $[\text{HBr}]$ is 0.329 mol/L. What was the initial $[\text{H}_2]$?

(4 marks)

4. Calculate the molar solubility of SrF_2 .

(4 marks)

5. Does a precipitate form when 3.0 mL of 1.0×10^{-3} M NaBr is added to 2.0 mL of 1.0×10^{-3} M $\text{Pb}(\text{NO}_3)_2$?

(4 marks)

6. Write the equation for the predominant reaction between HSO_4^- and H_2PO_4^- .

(2 marks)

7. A 0.20 M solution of a weak acid, HA, has a $\text{pH} = 1.32$.

Use calculations and the table of “Relative Strengths of Brønsted-Lowry Acids and Bases” from the *Data Booklet* to determine the identity of the acid.

(5 marks)

The acid is: _____

8. Calculate the pH of a solution prepared by mixing 15.0 mL of 0.50 M HCl with 35.0 mL of 1.0 M NaOH.

(4 marks)

9. Identify a gas which causes acid rain, and write an equation showing this gas reacting with water.

(2 marks)

10. Balance the following redox reaction in acidic solution.

(3 marks)



11. Aluminum is a stronger reducing agent than copper. What is meant by the term *stronger reducing agent*?

(2 marks)

12. Consider the electrolysis of water.

a) Draw and label the parts of an electrolytic cell capable of decomposing water. **(3 marks)**

b) Identify the gas produced at the anode.

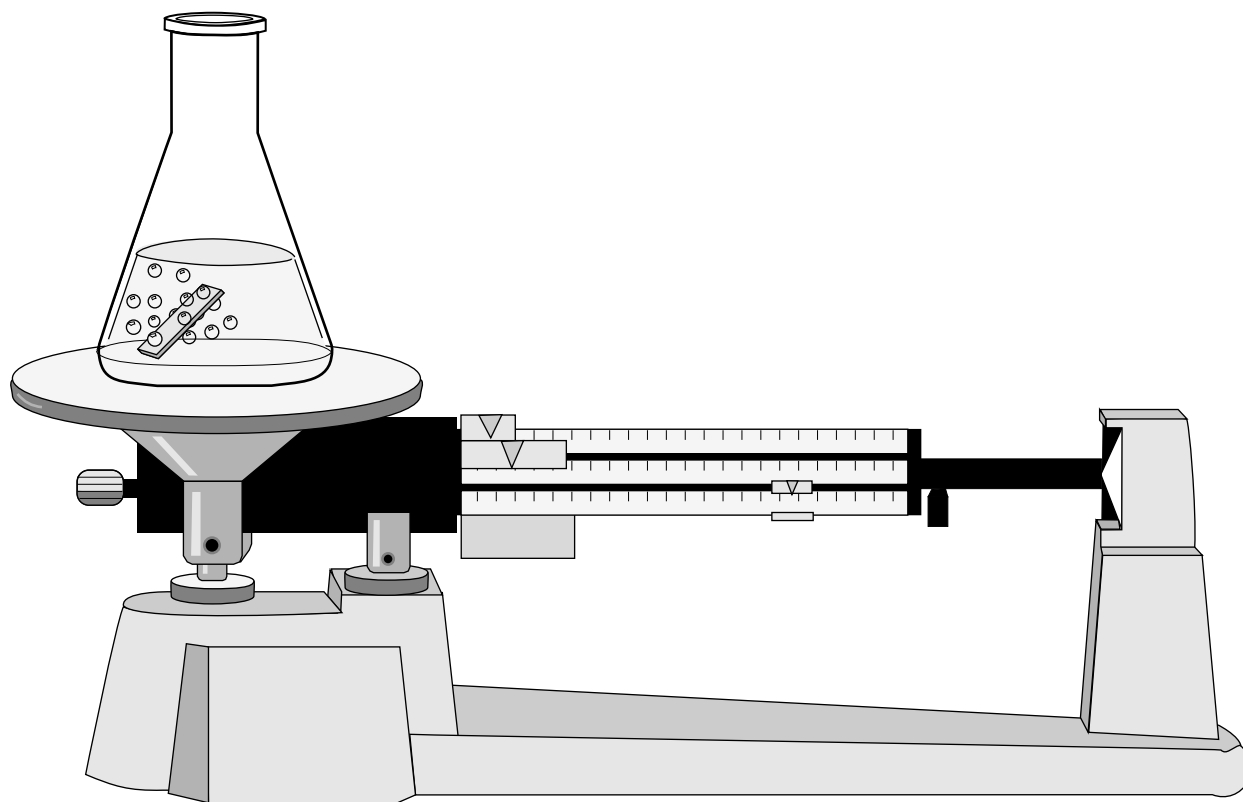
(1 mark)

END OF EXAMINATION

Data Booklet

CHEMISTRY 12

Work done in this booklet
will not be marked.



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Page	Table
1	Periodic Table of the Elements
2	Atomic Masses of the Elements
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6	Relative Strengths of Brønsted-Lowry Acids and Bases
7	Acid-base Indicators
8	Standard Reduction Potentials of Half-cells

REFERENCE

D.R. Lide, *CRC Handbook of Chemistry and Physics*, 80th edition, CRC Press, Boca Raton, 1999.

PERIODIC TABLE OF THE ELEMENTS

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													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													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 Db Dubnium (262)	106 Sg Seaborgium (263)	107 Bh Bohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (266)										103 Lr Lawrencium (262)												
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;"> 14 • Atomic Number Si • Symbol Silicon • Name 28.1 • Atomic Mass </div>																														
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;"> 58 Ce Cerium 140.1</div>																		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
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;"> 90 Th Thorium 232.0</div>																		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 C¹² at 12.00.
Values in parentheses are the mass number of the most stable or best
known isotopes for elements that do not occur naturally.*

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

NAMES, FORMULAE, AND CHARGES OF SOME COMMON IONS

* *Aqueous solutions are readily oxidized by air.*

** *Not stable in aqueous solutions.*

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

Negative Ions (Anions)			
Br^-	Bromide	OH^-	Hydroxide
CO_3^{2-}	Carbonate	ClO^-	Hypochlorite
ClO_3^-	Chlorate	I^-	Iodide
Cl^-	Chloride	HPO_4^{2-}	Monohydrogen phosphate
ClO_2^-	Chlorite	NO_3^-	Nitrate
CrO_4^{2-}	Chromate	NO_2^-	Nitrite
CN^-	Cyanide	$\text{C}_2\text{O}_4^{2-}$	Oxalate
$\text{Cr}_2\text{O}_7^{2-}$	Dichromate	O^{2-}	Oxide**
H_2PO_4^-	Dihydrogen phosphate	ClO_4^-	Perchlorate
CH_3COO^-	Ethanoate, acetate	MnO_4^-	Permanganate
F^-	Fluoride	PO_4^{3-}	Phosphate
HCO_3^-	Hydrogen carbonate, bicarbonate	SO_4^{2-}	Sulphate
HC_2O_4^-	Hydrogen oxalate, binoxalate	S^{2-}	Sulphide
HSO_4^-	Hydrogen sulphate, bisulphate	SO_3^{2-}	Sulphite
HS^-	Hydrogen sulphide, bisulphide	SCN^-	Thiocyanate
HSO_3^-	Hydrogen sulphite, bisulphite		

SOLUBILITY OF COMMON COMPOUNDS IN WATER

The term soluble here means > 0.1 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 ₂ O 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 ₂ CO ₃	8.5×10^{-12}
Silver chloride	AgCl	1.8×10^{-10}
Silver chromate	Ag ₂ CrO 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 BRØNSTED-LOWRY ACIDS AND BASES
in aqueous solution at room temperature.

Name of Acid	Acid	Base	K_a
Perchloric	HClO_4	$\rightarrow \text{H}^+ + \text{ClO}_4^-$	very large
Hydriodic	HI	$\rightarrow \text{H}^+ + \text{I}^-$	very large
Hydrobromic	HBr	$\rightarrow \text{H}^+ + \text{Br}^-$	very large
Hydrochloric	HCl	$\rightarrow \text{H}^+ + \text{Cl}^-$	very large
Nitric	HNO_3	$\rightarrow \text{H}^+ + \text{NO}_3^-$	very large
Sulphuric	H_2SO_4	$\rightarrow \text{H}^+ + \text{HSO}_4^-$	very large
Hydronium Ion	H_3O^+	$\rightleftharpoons \text{H}^+ + \text{H}_2\text{O}$	1.0
Iodic	HIO_3	$\rightleftharpoons \text{H}^+ + \text{IO}_3^-$	1.7×10^{-1}
Oxalic	$\text{H}_2\text{C}_2\text{O}_4$	$\rightleftharpoons \text{H}^+ + \text{HC}_2\text{O}_4^-$	5.9×10^{-2}
Sulphurous ($\text{SO}_2 + \text{H}_2\text{O}$)	H_2SO_3	$\rightleftharpoons \text{H}^+ + \text{HSO}_3^-$	1.5×10^{-2}
Hydrogen sulphate ion	HSO_4^-	$\rightleftharpoons \text{H}^+ + \text{SO}_4^{2-}$	1.2×10^{-2}
Phosphoric	H_3PO_4	$\rightleftharpoons \text{H}^+ + \text{H}_2\text{PO}_4^-$	7.5×10^{-3}
Hexaaquoiron ion, iron(III) ion	$\text{Fe}(\text{H}_2\text{O})_6^{3+}$	$\rightleftharpoons \text{H}^+ + \text{Fe}(\text{H}_2\text{O})_5(\text{OH})^{2+}$	6.0×10^{-3}
Citric	$\text{H}_3\text{C}_6\text{H}_5\text{O}_7$	$\rightleftharpoons \text{H}^+ + \text{H}_2\text{C}_6\text{H}_5\text{O}_7^-$	7.1×10^{-4}
Nitrous	HNO_2	$\rightleftharpoons \text{H}^+ + \text{NO}_2^-$	4.6×10^{-4}
Hydrofluoric	HF	$\rightleftharpoons \text{H}^+ + \text{F}^-$	3.5×10^{-4}
Methanoic, formic	HCOOH	$\rightleftharpoons \text{H}^+ + \text{HCOO}^-$	1.8×10^{-4}
Hexaaquochromium ion, chromium(III) ion	$\text{Cr}(\text{H}_2\text{O})_6^{3+}$	$\rightleftharpoons \text{H}^+ + \text{Cr}(\text{H}_2\text{O})_5(\text{OH})^{2+}$	1.5×10^{-4}
Benzoic	$\text{C}_6\text{H}_5\text{COOH}$	$\rightleftharpoons \text{H}^+ + \text{C}_6\text{H}_5\text{COO}^-$	6.5×10^{-5}
Hydrogen oxalate ion	HC_2O_4^-	$\rightleftharpoons \text{H}^+ + \text{C}_2\text{O}_4^{2-}$	6.4×10^{-5}
Ethanoic, acetic	CH_3COOH	$\rightleftharpoons \text{H}^+ + \text{CH}_3\text{COO}^-$	1.8×10^{-5}
Dihydrogen citrate ion	$\text{H}_2\text{C}_6\text{H}_5\text{O}_7^-$	$\rightleftharpoons \text{H}^+ + \text{HC}_6\text{H}_5\text{O}_7^{2-}$	1.7×10^{-5}
Hexaaquoaluminum ion, aluminum ion	$\text{Al}(\text{H}_2\text{O})_6^{3+}$	$\rightleftharpoons \text{H}^+ + \text{Al}(\text{H}_2\text{O})_5(\text{OH})^{2+}$	1.4×10^{-5}
Carbonic ($\text{CO}_2 + \text{H}_2\text{O}$)	H_2CO_3	$\rightleftharpoons \text{H}^+ + \text{HCO}_3^-$	4.3×10^{-7}
Monohydrogen citrate ion	$\text{HC}_6\text{H}_5\text{O}_7^{2-}$	$\rightleftharpoons \text{H}^+ + \text{C}_6\text{H}_5\text{O}_7^{3-}$	4.1×10^{-7}
Hydrogen sulphite ion	HSO_3^-	$\rightleftharpoons \text{H}^+ + \text{SO}_3^{2-}$	1.0×10^{-7}
Hydrogen sulphide	H_2S	$\rightleftharpoons \text{H}^+ + \text{HS}^-$	9.1×10^{-8}
Dihydrogen phosphate ion	H_2PO_4^-	$\rightleftharpoons \text{H}^+ + \text{HPO}_4^{2-}$	6.2×10^{-8}
Boric	H_3BO_3	$\rightleftharpoons \text{H}^+ + \text{H}_2\text{BO}_3^-$	7.3×10^{-10}
Ammonium ion	NH_4^+	$\rightleftharpoons \text{H}^+ + \text{NH}_3$	5.6×10^{-10}
Hydrocyanic	HCN	$\rightleftharpoons \text{H}^+ + \text{CN}^-$	4.9×10^{-10}
Phenol	$\text{C}_6\text{H}_5\text{OH}$	$\rightleftharpoons \text{H}^+ + \text{C}_6\text{H}_5\text{O}^-$	1.3×10^{-10}
Hydrogen carbonate ion	HCO_3^-	$\rightleftharpoons \text{H}^+ + \text{CO}_3^{2-}$	5.6×10^{-11}
Hydrogen peroxide	H_2O_2	$\rightleftharpoons \text{H}^+ + \text{HO}_2^-$	2.4×10^{-12}
Monohydrogen phosphate ion	HPO_4^{2-}	$\rightleftharpoons \text{H}^+ + \text{PO}_4^{3-}$	2.2×10^{-13}
Water	H_2O	$\rightleftharpoons \text{H}^+ + \text{OH}^-$	1.0×10^{-14}
Hydroxide ion	OH^-	$\leftarrow \text{H}^+ + \text{O}^{2-}$	very small
Ammonia	NH_3	$\leftarrow \text{H}^+ + \text{NH}_2^-$	very small

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 1M in water at 25°C.

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

Overpotential Effect

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