June 1998


# Chemistry 30

## Grade 12 Diploma Examination

Alberta EDUCATION

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*June 1998*

# *Chemistry 30*

## *Grade 12 Diploma Examination*

### *Description*

Time: 2.5 h. You may take an additional 0.5 h to complete the examination.

This is a **closed-book** examination consisting of

- 44 multiple-choice and 12 numerical-response questions, of equal value, worth 70% of the examination
- 2 written-response questions, each worth 15% of the examination

This examination contains sets of related questions

A set of questions may contain multiple-choice and/or numerical-response and/or written-response questions.

When required, a grey bar is used to indicate the end of a set.

A chemistry data booklet is provided for your reference.

The perforated pages at the back of this booklet may be torn out and used for your rough work. No marks will be given for work done on the tear-out pages.

### *Instructions*

- Fill in the information required on the answer sheet and the examination booklet as directed by the presiding examiner.
- You are expected to provide your own scientific calculator.
- Use only an HB pencil for the machine-scored answer sheet.
- If you wish to change an answer, erase **all** traces of your first answer.
- Consider all numbers used in the examination to be the result of a measurement or observation.
- Do not fold the answer sheet.
- The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education.
- Read each question carefully.
- Now turn this page and read the detailed instructions for answering machine-scored and written-response questions.

## *Multiple Choice*

- Decide which of the choices **best** completes the statement or answers the question.
- Locate that question number on the separate answer sheet provided and fill in the circle that corresponds to your choice.

***Example***

This examination is for the subject of

**A.** chemistry
**B.** biology
**C.** physics
**D.** science

Answer Sheet

● Ⓑ Ⓒ Ⓓ

## *Numerical Response*

- Record your answer on the answer sheet provided by writing it in the boxes and then filling in the corresponding circles.
- If an answer is a value between 0 and 1 (e.g., 0.25), then be sure to record the 0 before the decimal place.
- **Enter the first digit of your answer in the left-hand box and leave any unused boxes blank.**

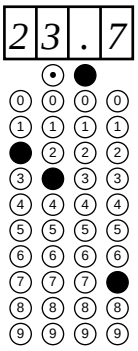
***Examples***

***Calculation Question and Solution***

The average of the values 21.0, 25.5, and 24.5 is _____.
(Record your answer to three digits on the answer sheet.)

Average = (21.0 + 25.5 + 24.5)/3
= 23.666
= 23.7 (rounded to three digits)

**Record 23.7 on the answer sheet** →



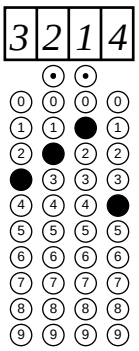
### *Correct-order Question and Solution*

When the following subjects are arranged in alphabetical order, the order is _____. (Record all four digits on the answer sheet.)

**1** physics
**2** chemistry
**3** biology
**4** science

Answer 3214

**Record 3214 on the answer sheet** →




## *Written Response*

- Write your answers in the examination booklet as neatly as possible.
- For full marks, your answers must be well organized and address **all** the main points of the question.
- Relevant scientific, technological, and/or societal concepts and examples must be identified and made explicit.
- Description and/or explanations of concepts must be correct and reflect pertinent ideas, calculations, and formulas.
- Your answers **should be** presented in a well-organized manner using complete sentences, correct units, and significant digits where appropriate.

**1.** A person who states that “all vehicles are really solar-powered” is implying that

**A.** all current vehicles operate on solar cells

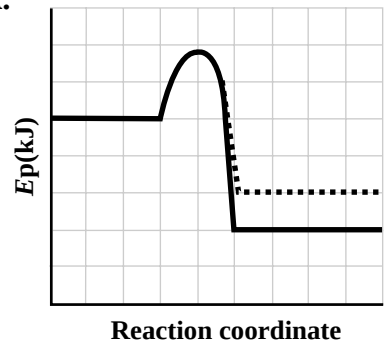
**B.** solar energy warms a vehicle’s interior on a sunny day

**C.** the energy stored in fossil fuels is a result of photosynthesis

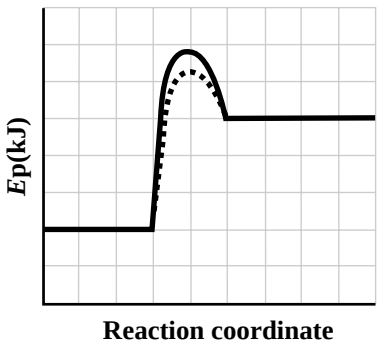
**D.** solar energy is the ideal renewable, non-polluting energy source

**2.** The graph that describes catalyzed (----) and uncatalyzed (▬) exothermic chemical reactions is

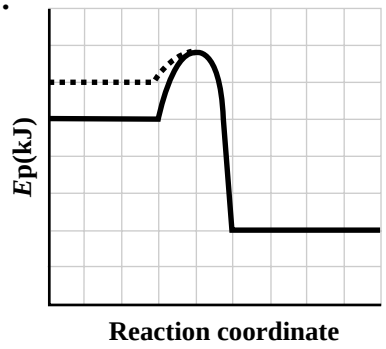
**A.**



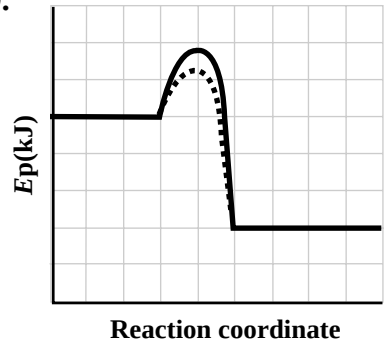

**B.**




**C.**




**D.**



Cancarb Ltd., a company located in Medicine Hat, produces high-quality carbon through the thermal decomposition of natural gas. The natural gas is heated in the absence of oxygen to 1300°C in a reaction chamber.

The reaction is represented by the equation

$$CH_{4(g)} \rightleftharpoons C_{(s)} + 2\,H_{2(g)}$$

**3.** In this decomposition, the

**A.** reactants have more potential energy than do the products

**B.** products have more potential energy than do the reactants

**C.** reactants have more kinetic energy than do the products

**D.** products have more kinetic energy than do the reactants

**Numerical Response**

**1.** The standard enthalpy required to completely decompose 1.00 mol of methane into carbon and hydrogen is _____ kJ.
(Record your answer to three digits on the answer sheet.)

**4.** The thermal decomposition process extracts only about 50% of the carbon from the natural gas. Some of the remaining carbon reacts to form carbon dioxide when it is released into the atmosphere. Which of the following statements relating to carbon dioxide is **false**?

**A.** Carbon dioxide reacts with moisture in the air to produce carbonic acid.

**B.** Carbon dioxide absorbs infrared radiation and radiates the energy back toward Earth.

**C.** Carbon dioxide attacks the ozone layer.

**D.** Carbon dioxide increases with deforestation.

**5.** The conditions that should maximize the amount of product formed are

**A.** low pressure and low temperature

**B.** low pressure and high temperature

**C.** high pressure and low temperature

**D.** high pressure and high temperature

**6.** When a sample of the high-quality carbon is soaked in distilled water, the resulting solution has a pH of approximately 10.0. This pH is probably caused by an impurity such as

**A.** $K_2SO_{4(aq)}$

**B.** $BaCl_{2(aq)}$

**C.** $Al(NO_3)_{3(aq)}$

**D.** $Na_2CO_{3(aq)}$

## Numerical Response

**2.** A solution prepared by mixing a sample of carbon with $NaCl_{(aq)}$ has a pH of 9.93. The pOH of this solution is _____.
(Record your answer to three digits on the answer sheet.)

**7.** The purity of high-quality carbon can be determined by soaking a sample in water and then measuring its pH. "Ultrapure" grade has a pH of 6.00, and "Thermax" grade has a pH of 10.00. The $[OH^-_{(aq)}]$ of these two grades of high-quality carbon are, respectively,

**A.** $1.0 \times 10^{-6}$ mol/L and $1.0 \times 10^{-10}$ mol/L

**B.** $1.0 \times 10^{-8}$ mol/L and $1.0 \times 10^{-4}$ mol/L

**C.** 4.0 mol/L and 8.0 mol/L

**D.** 8.0 mol/L and 4.0 mol/L

**8.** Thermax, $C_{(s)}$, is commonly used as a metallurgical reducing agent. Its reaction with chromium is represented by the **unbalanced** equation

$$\_\_\_Cr_2O_{3(s)} + \_\_\_C_{(s)} \rightarrow \_\_\_Cr_{(s)} + \_\_\_CO_{2(g)}$$

The production of 2.00 mol of $Cr_{(s)}$

**A.** releases 549.5 kJ

**B.** requires 549.5 kJ

**C.** releases 1098.9 kJ

**D.** requires 1098.9 kJ

**9.** The reaction of high-quality carbon with oxide mixtures produces durable carbon compounds. The oxidation numbers for the metals in the oxides of $TiO_{2(s)}$, $MoO_{3(s)}$, $W_4O_{12(s)}$, and $W_2O_{5(s)}$ are, respectively,

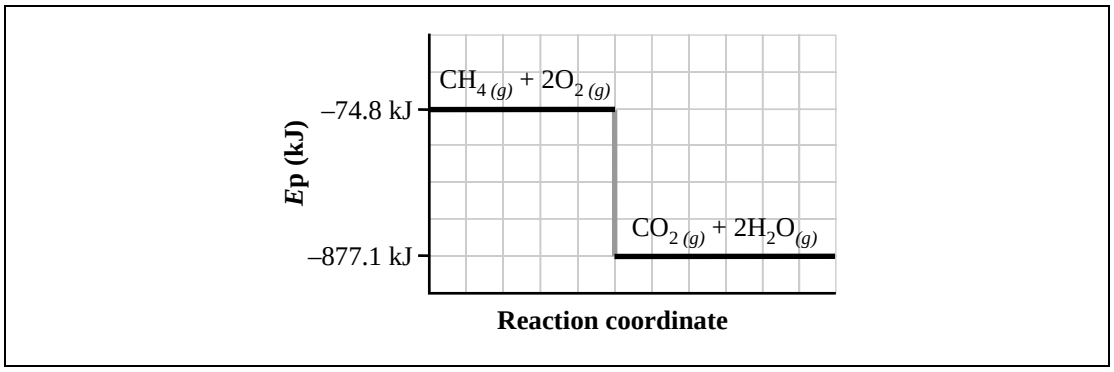
**A.** 4, 6, 24, and 10

**B.** 2, 3, 3, and $\frac{5}{2}$

**C.** 4, 6, 6, and 5

**D.** 2, 3, 24, and $\frac{5}{2}$

*Use the following information to answer the next question.*




**10.** The $\Delta H$ for the combustion reaction is

**A.** –951.9 kJ

**B.** +951.9 kJ

**C.** –802.3 kJ

**D.** +802.3 kJ

*Use the following information to answer the next question.*

At high temperatures, nitrogen and oxygen react to form nitrogen oxides.

**Reaction I** $\frac{1}{2}N_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow NO_{(g)}$ $\Delta H_f^\circ = +90.2$ kJ

**Reaction II** $\frac{1}{2}N_{2(g)} + O_{2(g)} \rightarrow NO_{2(g)}$ $\Delta H_f^\circ = +33.2$ kJ

The reddish-brown colour of smog is a result of a reaction between $NO_{(g)}$ and $O_{2(g)}$ to produce $NO_{2(g)}$.

**Numerical Response**

**3.** The heat energy released by the reaction $NO_{(g)} + \frac{1}{2}O_{2(g)} \rightarrow NO_{2(g)}$ is _____ kJ.
(Record your answer to three digits on the answer sheet.)

**Numerical Response**

**4.** To compare energy magnitudes, four identical samples of a metallic element were subjected to the following changes.

**1** The first sample was heated through a temperature change of one degree Celsius.

**2** The second sample was converted to a new element.

**3** The third sample was reacted with oxygen.

**4** The last sample was melted.

Listed in order of increasing energy, the changes are ___ , ___ , ___ , and ___ .
(Record four digits on the answer sheet.)

*Use the following terms to answer the next question.*

| | | | |
|---|---|---|---|
| **1** | solar | **5** | potential |
| **2** | heat | **6** | kinetic |
| **3** | intranuclear | **7** | endothermic |
| **4** | intramolecular | **8** | exothermic |

**Numerical Response**

*Use the numbers from the terms listed above to complete these statements.*

**5.** During the process of photosynthesis, _____ energy is used to rearrange _____ bonds. This results in an increase in _____ energy. During cellular respiration or combustion, the stored energy is released in a/an _____ process.
(Record all four digits, in the order presented, on the answer sheet.)

_____

*Use the following information to answer the next question.*

| | **Types of Molecular Motion** | | |
|---|---|---|---|
| | **Translational** | **Rotational** | **Vibrational** |
| **Phase I** | free | free | free |
| **Phase II** | restricted | restricted | free |
| **Phase III** | absent | very restricted | free |

**11.** Phases I, II, and III are, respectively,

**A.** a solid, a liquid, and a gas
**B.** a solid, a gas, and a liquid
**C.** a gas, a liquid, and a solid
**D.** a gas, a solid, and a liquid

*Use the following equations to answer the next question.*

**Reaction I** $^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{143}_{56}\mathrm{Ba} + {}^{91}_{36}\mathrm{Kr} + 2\,{}^{1}_{0}\mathrm{n}$

**Reaction II** $4\,{}^{1}_{1}\mathrm{H} + 2\,{}^{0}_{-1}\mathrm{e} \rightarrow {}^{4}_{2}\mathrm{He}$

**12.** Which of the following statements about the equations is true?

**A.** Both are fusion reactions.
**B.** Both are fission reactions.
**C.** Reaction I is fusion and reaction II is fission.
**D.** Reaction I is fission and reaction II is fusion.

---

**13.** Which of the following changes is **not** an example of oxidation?

**A.** Corrosion of metals
**B.** Plating of metals
**C.** Rusting of iron
**D.** Reaction at the anode of a battery

**14.** An equation that represents a redox reaction is

**A.** $NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$
**B.** $AgNO_{3(aq)} + KI_{(aq)} \rightarrow AgI_{(s)} + KNO_{3(aq)}$
**C.** $Mg(OH)_{2(s)} + H_2SO_{4(aq)} \rightarrow MgSO_{4(aq)} + 2\,H_2O_{(l)}$
**D.** $Cu_{(s)} + 4\,HNO_{3(aq)} \rightarrow Cu(NO_3)_{2(aq)} + 2\,NO_{2(g)} + 2\,H_2O_{(l)}$

*Use the following equation to answer the next question.*

$$NH_{3(g)} + O_{2(g)} \rightarrow NO_{2(g)} + H_2O_{(g)}$$

**Numerical Response**

**6.** When balanced in terms of lowest whole numbers, the coefficients for this equation are, respectively, ___ , ___ , ___ , and ___ .
(Record all four digits on the answer sheet.)

---

**15.** A spontaneous reaction would occur between a 1.0 mol/L $Fe^{3+}_{(aq)}$ solution and

**A.** $I_{2(s)}$
**B.** $Zn_{(s)}$
**C.** $Hg_{(l)}$
**D.** 1.0 mol/L $Fe^{2+}_{(aq)}$

*Use the following information to answer the next question.*

Metals $E_{(s)}$, $Q_{(s)}$, $R_{(s)}$, and $P_{(s)}$ react with metallic ions to produce the following results:

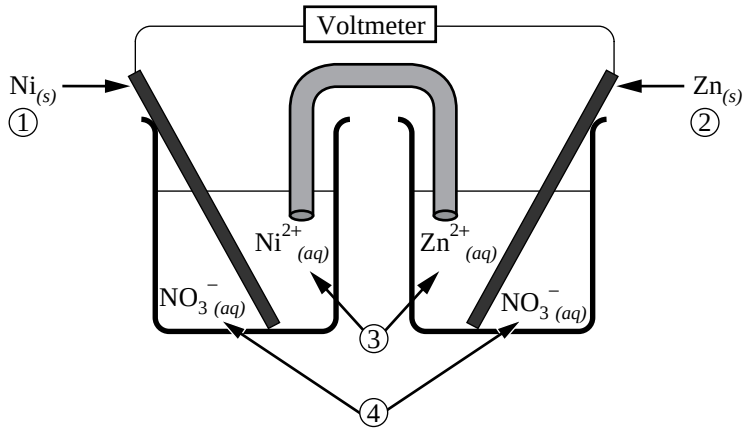
$$Q^{2+}_{(aq)} + 2R_{(s)} \rightarrow Q_{(s)} + 2R^{+}_{(aq)}$$
$$Q^{2+}_{(aq)} + E_{(s)} \rightarrow \text{No Reaction}$$
$$2P^{+}_{(aq)} + E_{(s)} \rightarrow 2P_{(s)} + E^{2+}_{(aq)}$$

**16.** The strongest oxidizing agent is

**A.** $R^{+}_{(aq)}$
**B.** $Q^{2+}_{(aq)}$
**C.** $E^{2+}_{(aq)}$
**D.** $P^{+}_{(aq)}$

*Use the following information to answer the next question.*

**Electrochemical Cell**




**Numerical Response**

**7.** Match each term with the appropriate number on the diagram.

Anode _____ (Record in first column)
Cathode _____ (Record in second column)
Anions _____ (Record in third column)
Cations _____ (Record in fourth column)

**17.** For the standard reference half-cell, the oxidation half-reaction and $E°$ are

**A.** $H_{2(g)} \rightarrow 2\,H^{+}_{(aq)} + 2\,e^{-}$ $\quad E° = 0.00$ V

**B.** $2\,H^{+}_{(aq)} + 2\,e^{-} \rightarrow H_{2(g)}$ $\quad E° = 0.00$ V

**C.** $2\,H_2O_{(l)} + 2\,e^{-} \rightarrow H_{2(g)} + 2\,OH^{-}_{(aq)}$ $\quad E° = -0.83$ V

**D.** $H_{2(g)} + 2\,OH^{-}_{(aq)} \rightarrow 2\,e^{-} + 2\,H_2O_{(l)}$ $\quad E° = +0.83$ V

**18.** Electrolytic cells are used commercially in

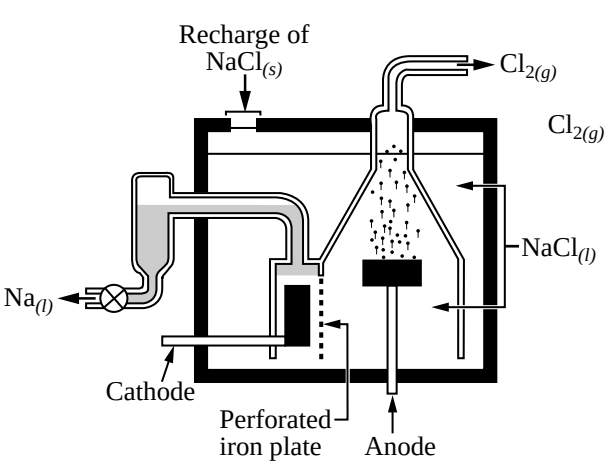
**A.** cameras

**B.** fuel cells

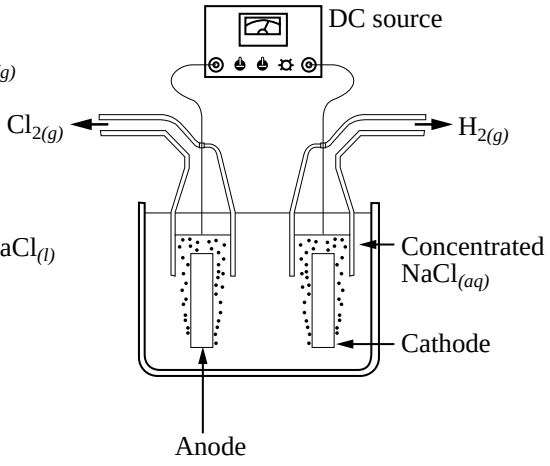
**C.** flashlights

**D.** metal plating

The electrolysis of molten sodium chloride ($NaCl_{(l)}$) in the Downs Cell and the electrolysis of brine ($NaCl_{(aq)}$) are two important industrial applications of electrolysis. They produce large quantities of chlorine gas, hydrogen gas, sodium hydroxide, and sodium metal. All of these products have important industrial uses. The design of these cells is illustrated below.




**Electrolysis of Molten Sodium Chloride**




**Electrolysis of Brine**

**19.** In both cells, the design is such that the products of the electrolysis reactions are removed. If the products were not removed, they would

**A.** react with the original reactants

**B.** react with the electrodes

**C.** react spontaneously with each other

**D.** shift the equilibrium to the left

**20.** The Downs Cell operates at a high temperature so that the sodium chloride is maintained in the liquid state. The design of this cell suggests that

**A.** $Cl_{2(l)}$ is very soluble in $NaCl_{(l)}$

**B.** $Na_{(l)}$ is less dense than $NaCl_{(l)}$

**C.** $Na_{(l)}$ is soluble in $NaCl_{(l)}$

**D.** $Na_{(l)}$ could react spontaneously with $NaCl_{(l)}$

**21.** Sodium metal is **not** produced in the electrolysis of brine because

**A.** $Na_{(s)}$ sodium metal reacts spontaneously with $H_2O_{(l)}$

**B.** $Cl^-_{(aq)}$ is more readily reduced than $Na^+_{(aq)}$

**C.** $H_2O_{(l)}$ is more readily oxidized than $Cl^-_{(aq)}$

**D.** $H_2O_{(l)}$ is more readily reduced than $Na^+_{(aq)}$

**22.** An electron flow of 12.0 A is used in the electrolysis of molten sodium chloride. The time required to produce 1.00 kg of $Na_{(l)}$ is

**A.** 2.23 h

**B.** 48.6 h

**C.** 97.2 h

**D.** 194 h

**23.** The products of the electrolysis of brine can be used to produce $HCl_{(g)}$. A saturated solution of $HCl_{(aq)}$ has a concentration of 12.2 mol/L. What mass of $NaCl_{(s)}$ must be consumed to produce 100 L of this $HCl_{(aq)}$?

**A.** 44.5 kg

**B.** 71.3 kg

**C.** 89.0 kg

**D.** 143 kg

**24.** The concentration of $Sn^{2+}_{(aq)}$ ions in a solution could most quickly and accurately be determined in a high school laboratory by performing

**A.** a redox titration

**B.** an acid–base titration

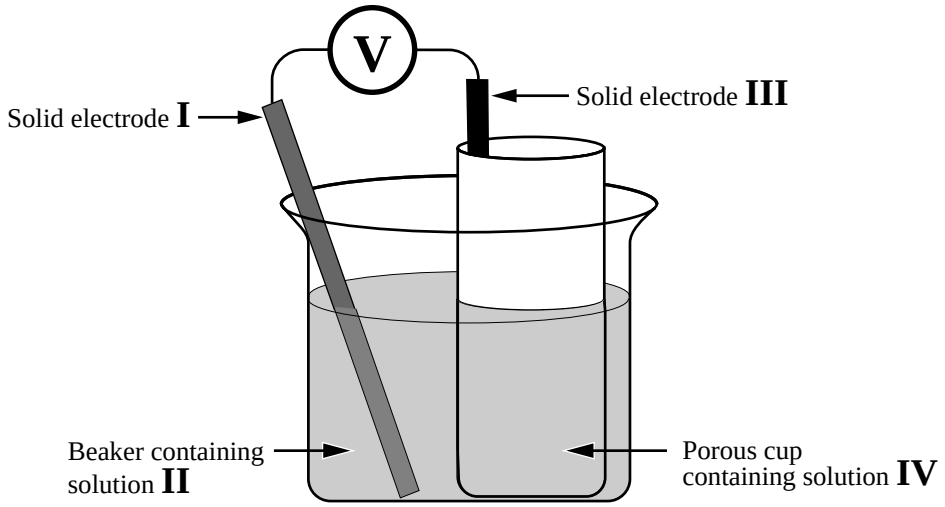
**C.** a precipitation reaction

**D.** a calorimetry experiment

*Use the following information to answer the next question.*

**Reagents**

| | | | |
|---|---|---|---|
| **1** | $Ag_{(s)}$ | **5** | 1.0 mol/L $Fe^{2+}_{(aq)}$ |
| **2** | $Cd_{(s)}$ | **6** | 1.0 mol/L $Hg^{2+}_{(aq)}$ |
| **3** | $Hg_{(l)}$ | **7** | 1.0 mol/L $Cd^{2+}_{(aq)}$ |
| **4** | $Fe_{(s)}$ | **8** | 1.0 mol/L $Ag^{+}_{(aq)}$ |




**Numerical Response**

**8.** What reagents are required in order for the cell to produce a voltage of 1.25 V?

Electrode I _____ (Record in first column)
Solution II _____ (Record in second column)
Electrode III _____ (Record in third column)
Solution IV _____ (Record in fourth column)

**25.** Red cabbage boiled in a dilute, household cleaning solution produces a bright green solution. When a person blows into the solution through a straw, the solution turns blue. The cabbage solution is an example of

**A.** an acid

**B.** an oxidizing agent

**C.** a reducing agent

**D.** an indicator

**26.** A conjugate acid–base pair is

**A.** $CH_3COOH_{(aq)}$ and $CO_3^{2-}{}_{(aq)}$

**B.** $HCO_3^-{}_{(aq)}$ and $CO_3^{2-}{}_{(aq)}$

**C.** $H_2S_{(aq)}$ and $H_2PO_4^-{}_{(aq)}$

**D.** $OH^-{}_{(aq)}$ and $CO_3^{2-}{}_{(aq)}$

*Use the following information to answer the next question.*

A 10.0 mL sample of $CH_3COOH_{(aq)}$ is titrated to the equivalence point with 35.0 mL of 0.0714 mol/L $NaOH_{(aq)}$.

**27.** The concentration of the $CH_3COOH_{(aq)}$ is

**A.** 2.04 mol/L

**B.** 0.250 mol/L

**C.** 0.125 mol/L

**D.** 0.0200 mol/L

---

*Use the following information to answer the next three questions.*

| **Hydrogen Halides** | **H–X Bond Energy (kJ/mol)** | **Melting Point (°C)** | **$\Delta H°_f$ (kJ/mol)** | **$K_a$** |
|---|---|---|---|---|
| HF | 565 | –83 | –271.1 | $6.6 \times 10^{-4}$ |
| HCl | 427 | –114 | –92.3 | $1.3 \times 10^{6}$ |
| HI | 363 | –87 | +26.5 | $3.2 \times 10^{9}$ |
| HBr | 295 | –51 | –36.4 | $1.0 \times 10^{9}$ |

**28.** The hydrogen halides, ordered from the strongest acid to weakest acid, are

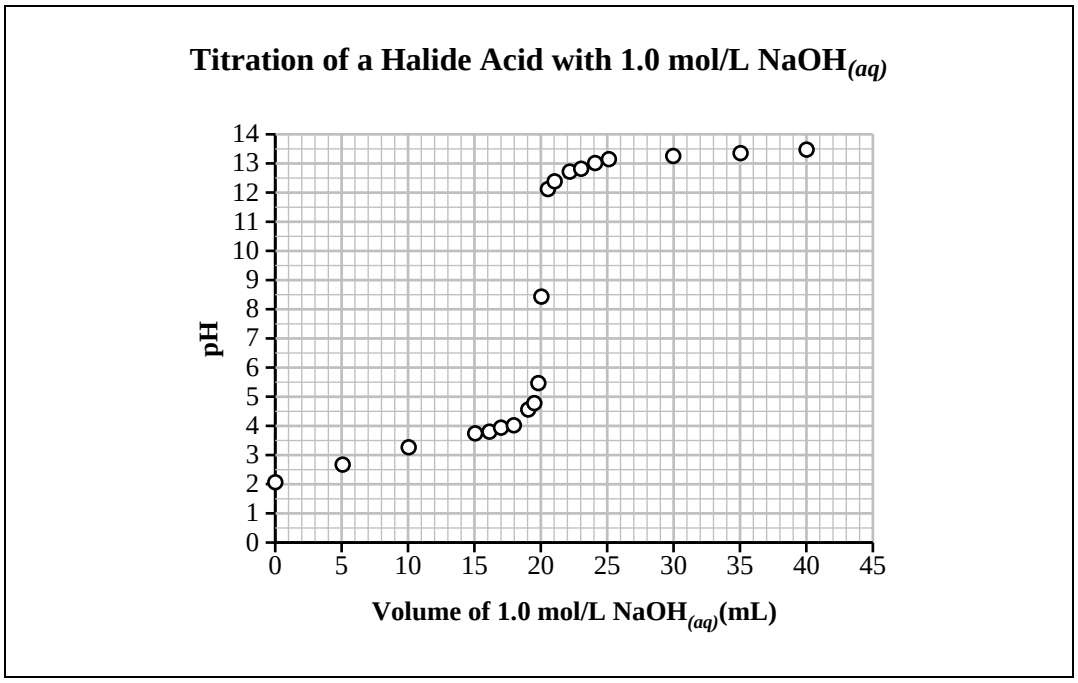
**A.** HI, HBr, HCl, HF

**B.** HBr, HI, HCl, HF

**C.** HBr, HCl, HI, HF

**D.** HF, HI, HCl, HBr

*Use the following additional information to answer the next two questions.*




**29.** The halide acid that would generate the data on the graph is

**A.** $HF_{(aq)}$
**B.** $HCl_{(aq)}$
**C.** $HI_{(aq)}$
**D.** $HBr_{(aq)}$

**30.** The indicator that would best signal the endpoint of this titration is

**A.** methyl orange
**B.** phenolphthalein
**C.** indigo carmine
**D.** bromothymol blue

Combustion of unscrubbed fossil fuels releases sulphur oxides into the air. These sulphur oxides eventually form $H_2SO_{3(aq)}$ and $H_2SO_{4(aq)}$ when combined with water vapour. The presence of these and other components of acid rain cause the pH of "normal" rain to decrease from about 6.00 to a recorded low of 2.30 in some areas.

**31.** One property of acid rain is that it

**A.** turns red litmus blue

**B.** tastes bitter

**C.** reacts with active metals

**D.** feels slippery

**32.** Indicators are added to three samples of acid rain from the same source. The samples with methyl orange and chlorophenol red are yellow. The sample with methyl red is red. The approximate pH of the acid rain samples is

**A.** 3.0

**B.** 4.6

**C.** 5.0

**D.** 5.5

**33.** The pH of a lake affected by acid rain could be adjusted to "normal" levels through the addition of

**A.** $CH_3OH_{(l)}$

**B.** $HCl_{(aq)}$

**C.** $NaCl_{(s)}$

**D.** $CaCO_{3(s)}$

**34.** In a highly industrialized area, the rain has an average pH of 4.5, but the pH of the soil has not changed enough to affect plant growth. The best explanation is that the

**A.** soil has a good buffering capacity

**B.** acid is not completely dissociated

**C.** plants are resistant to an increase in pH

**D.** soil has a high concentration of hydronium ions

---

**35.** The Brønsted–Lowry equation for the dissociation of sulphurous acid in aqueous solution is

**A.** $H_2SO_{3(aq)} + H_2O_{(l)} \rightleftharpoons SO_4^{2-}{}_{(aq)} + 2H^+{}_{(aq)} + 2e^-$

**B.** $H_2SO_{3(aq)} + 2H_2O_{(l)} \rightleftharpoons SO_3^{2-}{}_{(aq)} + 2H_3O^+{}_{(aq)}$

**C.** $H_2SO_{3(aq)} + H_2O_{(l)} \rightleftharpoons HSO_3^-{}_{(aq)} + H_3O^+{}_{(aq)}$

**D.** $H_2SO_{3(aq)} \rightleftharpoons SO_4^{2-}{}_{(aq)} + 2H^+{}_{(aq)}$

*Use the following information to answer the next three questions.*

A student titrated samples of sulphurous acid with a potassium permanganate solution.

**36.** The balanced net ionic equation for the titration is

**A.** $2MnO_4^-{}_{(aq)} + 5H_2SO_{3(aq)} + 6H^+{}_{(aq)} \rightarrow 2Mn^{2+}{}_{(aq)} + 5SO_4^{2-}{}_{(aq)} + 3H_2O_{(l)}$

**B.** $2MnO_4^-{}_{(aq)} + 5H_2SO_{3(aq)} \rightarrow 2Mn^{2+}{}_{(aq)} + 5SO_4^{2-}{}_{(aq)} + 4H^+{}_{(aq)} + 3H_2O_{(l)}$

**C.** $2MnO_4^-{}_{(aq)} + 5H_2SO_{3(aq)} + 16H^+{}_{(aq)} \rightarrow 2Mn^{2+}{}_{(aq)} + 5SO_4^{2-}{}_{(aq)} + 20H^+{}_{(aq)} + 3H_2O_{(l)}$

**D.** $2MnO_4^-{}_{(aq)} + 5SO_4^{2-}{}_{(aq)} + 36H^+{}_{(aq)} \rightarrow 2Mn^{2+}{}_{(aq)} + 5H_2SO_{3(aq)} + 13H_2O_{(l)}$

*Use the following additional information to answer the next two questions.*

**Titration of Sulphurous Acid with Potassium Permanganate**

Volume of sulphurous acid samples = 100.0 mL
Concentration of $KMnO_{4(aq)}$ = 0.0310 mol/L

| | **Volume of $KMnO_{4(aq)}$** | | | |
|---|---|---|---|---|
| **Trial** | **1** | **2** | **3** | **4** |
| Final buret reading (mL) | 9.50 | 18.15 | 26.75 | 34.75 |
| Initial buret reading (mL) | 1.00 | 9.50 | 18.15 | 26.75 |
| Final colour of mixture | pink | pink | pink | colourless |

**Numerical Response**

**9.** To determine the concentration of the sulphurous acid, the average volume of potassium permanganate used is _____ mL.
(Record your answer to three digits on the answer sheet.)

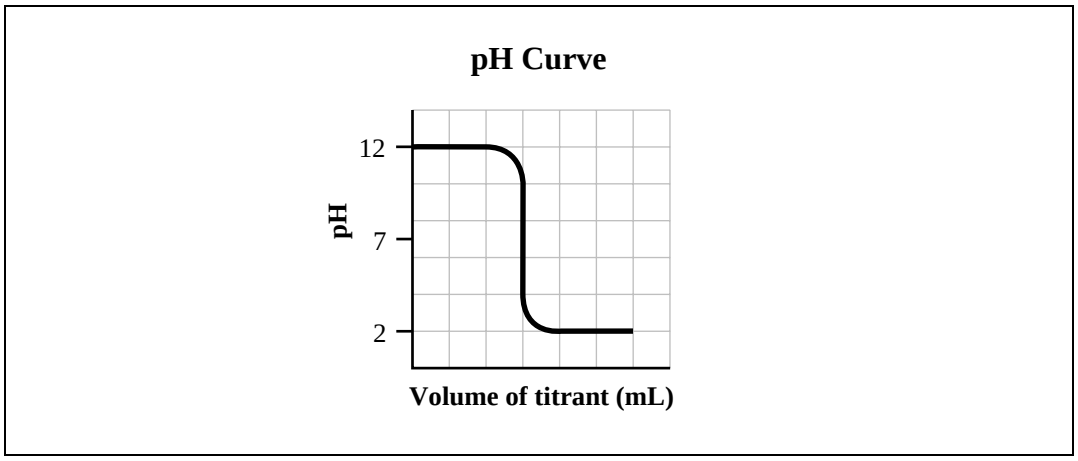
*Use the value selected for **Numerical Response 9** to answer **Numerical Response 10**.**

**Numerical Response**

**10.** The concentration of sulphurous acid in the sample is _____ mmol/L.
(Record your answer to three digits on the answer sheet.)

***You can receive marks for this question even if the previous question was answered incorrectly.**

*Use the following graph to answer the next question.*




**37.** The graph represents the titration of

**A.** sodium hydroxide with hydrochloric acid
**B.** potassium hydroxide with oxalic acid
**C.** hydrochloric acid with ammonia
**D.** acetic acid with sodium hydroxide

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## Numerical Response

**11.** When 0.10 mol of $NH_4NO_{3(s)}$ is dissolved in water to produce 1.0 L of solution, the pH of the solution is _____.
(Record your answer to three digits on the answer sheet.)

**38.** An acid that is **not** polyprotic is

**A.** $HOOCCOOH_{(aq)}$
**B.** $H_2BO_3^-{}_{(aq)}$
**C.** $HCOOH_{(aq)}$
**D.** $H_2SO_{4(aq)}$

**39.** In all chemical systems at equilibrium,

**A.** macroscopic properties are changing
**B.** all the reactants are converted to products
**C.** the amount of reactants equals the amount of products
**D.** the forward reaction rate equals the reverse reaction rate

**40.** For the steam–hydrocarbon reforming process, the equilibrium law expression is:

$$K_{\text{eq}} = \frac{[CO_{2(g)}][H_{2(g)}]^4}{[CH_{4(g)}][H_2O_{(g)}]^2}$$

The reaction described by this equilibrium is

**A.** $CH_{4(g)} + 2\,H_2O_{(g)} \rightleftharpoons CO_{2(g)} + 4\,H_{2(g)}$
**B.** $CO_{2(g)} + 4\,H_{2(g)} \rightleftharpoons CH_{4(g)} + 2\,H_2O_{(g)}$
**C.** $CH_{4(g)} + H_2O_{(g)} \rightleftharpoons CO_{2(g)} + H_{2(g)}$
**D.** $CO_{2(g)} + H_{2(g)} \rightleftharpoons CH_{4(g)} + H_2O_{(g)}$

Tooth decay results from the dissolving of tooth enamel, $Ca_5(PO_4)_3OH_{(s)}$. This decay is represented by the equilibrium equation

$$Ca_5(PO_4)_3OH_{(s)} \rightleftharpoons 5\,Ca^{2+}_{(aq)} + 3\,PO_4^{3-}{}_{(aq)} + OH^-_{(aq)}$$

**41.** When sugar ferments on teeth, the pH level inside the mouth decreases. Tooth enamel

**A.** is formed as the concentration of the phosphate ion decreases and the equilibrium shifts to the left

**B.** is formed as the concentration of the hydroxide ion decreases and the equilibrium shifts to the left

**C.** dissolves as the concentration of the hydroxide ion decreases and the equilibrium shifts to the right

**D.** dissolves as the concentration of calcium ion decreases and the equilibrium shifts to the right

**42.** If the equilibrium constant, $K_{eq}$, for the dissolving of tooth enamel has a value of $2.07 \times 10^{-30}$, then the $K_{eq}$ value for the reverse reaction is

**A.** $4.83 \times 10^{29}$

**B.** $4.83 \times 10^{15}$

**C.** $2.07 \times 10^{-16}$

**D.** $-2.07 \times 10^{-30}$

**43.** Most toothpastes contain fluoride compounds that mineralize tooth enamel forming $Ca_5(PO_4)_3F_{(s)}$. The $Ca_5(PO_4)_3F_{(s)}$ is more resistant to decay in an acidic medium than $Ca_5(PO_4)_3OH_{(s)}$ because fluoride is a

**A.** stronger base than hydroxide ion and is more likely to react

**B.** weaker base than hydroxide ion and is more likely to react

**C.** weaker base than hydroxide ion and is less likely to react

**D.** stronger base than hydroxide ion and is less likely to react

**44.** Tin(II) fluoride is one of the fluorides present in toothpaste. In the reaction $Sn_{(s)} + F_{2(g)} \rightarrow SnF_{2(s)}$, tin metal is the

**A.** oxidizing agent and is oxidized

**B.** reducing agent and is oxidized

**C.** reducing agent and is reduced

**D.** oxidizing agent and is reduced

## Numerical Response

**12.** A person with mercury amalgam fillings experiences an uncomfortable sensation when biting down on a piece of aluminum foil. The most likely reduction half-reaction has a potential of +0.85 V. Assume standard conditions. The net voltage that produces the uncomfortable sensation is +_____ V.
(Record your answer to three digits on the answer sheet.)

***For Department Use Only***

*Use the following information to answer the next question.*

Prestone Driveway Heat™ is used to melt ice from driveways in the winter. Driveway Heat™ is composed of calcium chloride and can melt ice at temperatures as low as –31.0°C.

**Written Response – 15%**

**1.** **a.** Determine the heat required to convert 200.0 g of ice at –31.0°C to liquid water at its melting point.

*For Department Use Only*

**b.** The following data were collected in an experiment designed to determine the molar heat of solution of Driveway Heat™ (assume pure calcium chloride):

| | |
|---|---|
| mass of Driveway Heat™ | 11.10 g |
| mass of Styrofoam™ cups | 7.90 g |
| mass of water and Styrofoam™ cups | 110.49 g |
| initial temperature of water | 22.7°C |
| highest temperature obtained | 40.1°C |

Determine the molar heat of solution of Driveway Heat™.

**c.** Give one possible advantage and one possible disadvantage of using this product to clear a driveway.

*Use the following information to answer the next question.*

The unique flavour of fruits and berries is due to the presence of esters, chemical compounds that are easily synthesized in the laboratory. For example, ethyl propanoate is responsible for the flavour characteristic to pineapple. It is produced by the reaction

$$C_2H_5OH_{(l)} + C_2H_5COOH_{(l)} \rightleftharpoons C_2H_5COOC_2H_{5(l)} + H_2O_{(l)}$$

When 7.71 mol of $C_2H_5OH_{(l)}$ and 7.37 mol of $C_2H_5COOH_{(l)}$ are reacted in a beaker, 4.80 mol of $C_2H_5COOC_2H_{5(l)}$ are present when equilibrium is established and the total volume of liquid is exactly 1.00 L.

**Written Response – 15%**

**2.** Calculate $K_{eq}$ for this system. Are the reactants or products favoured at equilibrium? Justify your choice.

***You have now completed the examination.***
***If you have time, you may wish to check your answers.***

***Tear-out Page***

***No marks will be given for work done on this page.***

*Fold and tear along perforation.*

***Tear-out Page***

***No marks will be given for work done on this page.***

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