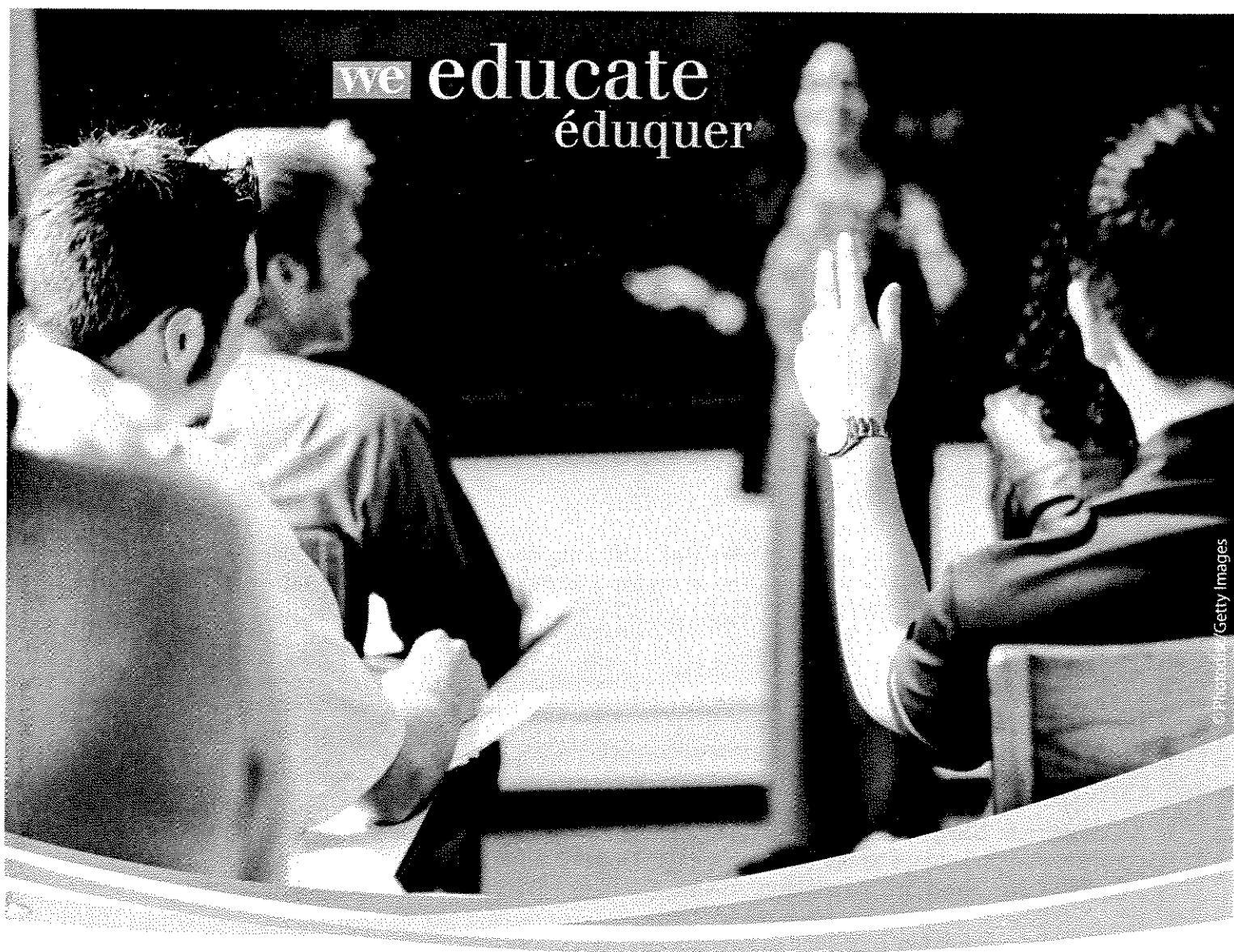


Chemistry 30

Released Items

2009 Released Diploma Examination Items



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Introduction

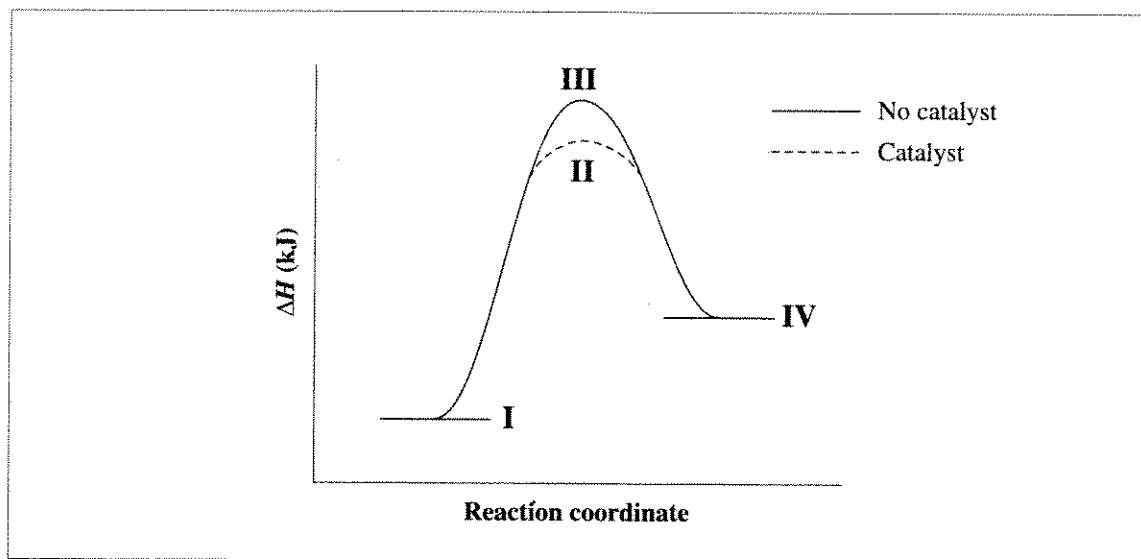
The questions presented in this booklet are from the January 2009 Chemistry 30 Diploma Examination. This material, along with the program of studies, Subject Bulletin, Assessment Highlights, and January 2009 Diploma Examination Results, can provide insights that assist you with decisions relative to instructional programming.

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Chemistry 30 Diploma Examination January 2009,
Part B: Multiple-Choice and Numerical-Response Questions

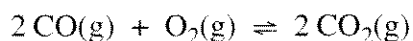
Use the following information to answer the first question.



1. The activation energy for the forward, catalyzed reaction is
- A. II minus I
 - B. III minus I
 - C. IV minus II
 - D. IV minus III

Use the following information to answer the next question.

Incomplete combustion in motor vehicles may lead to the formation of carbon monoxide gas, which is a health hazard in high concentrations. Carbon monoxide gas is converted to carbon dioxide gas in a catalytic converter before being emitted from the motor vehicle. This conversion is represented by the equation below.



2. The addition of a catalyst to the reaction represented by the equation above would *i* the energy transferred during the reaction and would *ii* the value of the equilibrium constant.

The statement above is completed by the information in row

Row	<i>i</i>	<i>ii</i>
A.	increase	increase
B.	increase	not change
C.	not change	increase
D.	not change	not change

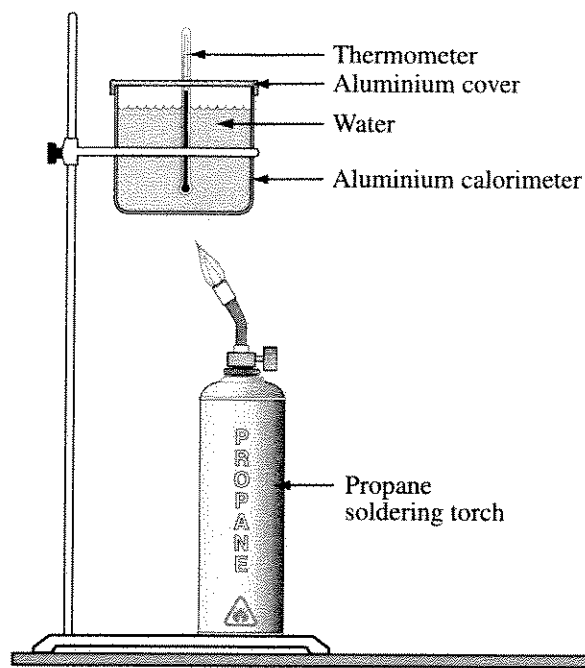
Use the following information to answer the next question.

Honey has a high concentration of fructose, $\text{C}_6\text{H}_{12}\text{O}_6\text{(s)}$. Fructose has the same molecular formula as glucose but a different structural formula.

3. If 1.50 mmol of fructose is burned in a calorimeter that contains 250.0 g of water and the temperature increases by 3.85°C , then the molar enthalpy of combustion of fructose is
- A. $-6.05 \times 10^{-3} \text{ kJ/mol}$
B. $-9.68 \times 10^{-2} \text{ kJ/mol}$
C. -4.03 kJ/mol
D. $-2.69 \times 10^3 \text{ kJ/mol}$

Use the following information to answer the next question.

A technician performed an experiment to determine the molar enthalpy of combustion of propane in a soldering torch, as represented in the diagram below.



4. If the experimental value of the molar enthalpy of combustion of propane in the technician's calorimetry experiment is significantly different from the theoretical value, then the technician could reduce the discrepancy in the data by
- A. using a glass beaker to hold the water
 - B. creating an enclosing shield around the apparatus
 - C. raising the aluminium calorimeter above the flame
 - D. decreasing the mass of water in the aluminium calorimeter

5. During a combustion reaction, energy is *i* the surroundings because the products have *ii* potential energy than the reactants.

The statement above is completed by the information in row

Row	<i>i</i>	<i>ii</i>
A.	released to	lower
B.	released to	higher
C.	absorbed from	lower
D.	absorbed from	higher

Use the following information to answer the next question.

Chemicals			
1	O ₂ (g)	4	H ₂ O(l)
2	CO(g)	5	H ₂ O(g)
3	CO ₂ (g)	6	C ₆ H ₁₂ O ₆ (aq)

Numerical Response

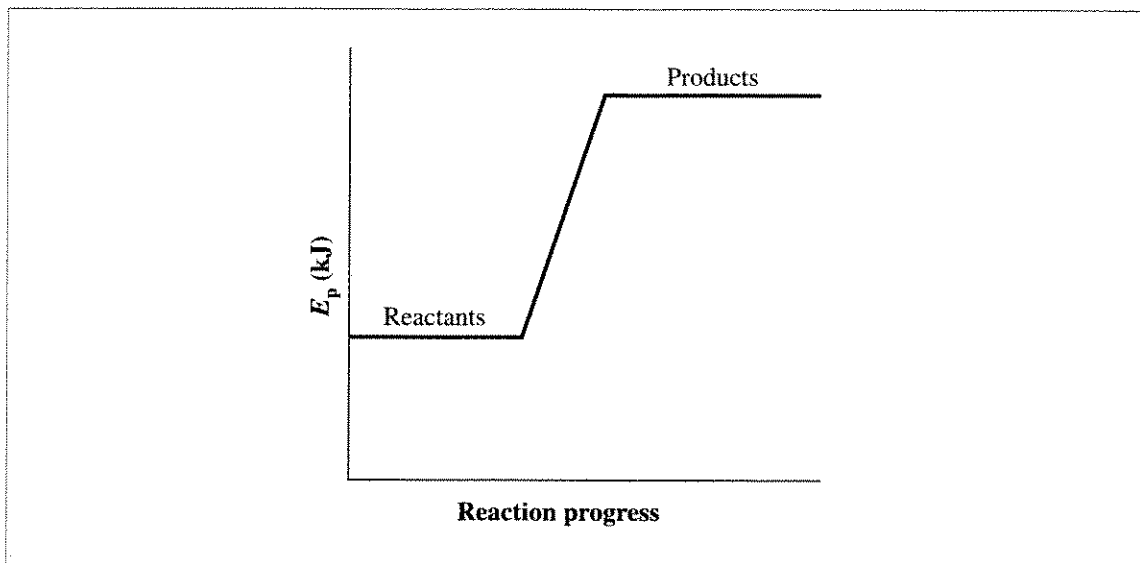
1. Match the chemicals numbered above with the statements given below.

The reactants of photosynthesis are: _____ and _____ .
Record in the **first** column Record in the **second** column

The products of complete hydrocarbon combustion in an open system are: _____ and _____ .
Record in the **third** column Record in the **fourth** column

(Record your answer in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.



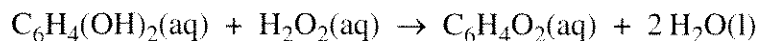
6. The reaction represented in the diagram above is *i* , and if the energy was included as a term in the balanced equation, it would be a *ii* .

The statement above is completed by the information in row

Row	<i>i</i>	<i>ii</i>
A.	exothermic	reactant
B.	exothermic	product
C.	endothermic	reactant
D.	endothermic	product

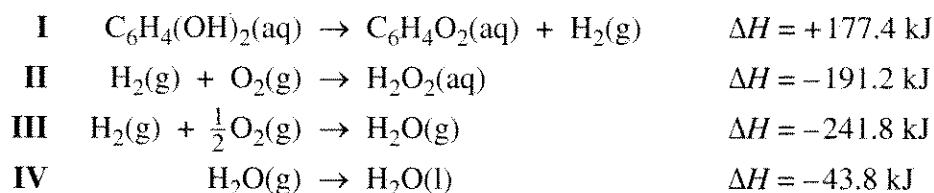
Use the following information to answer the next two questions.

The bombardier beetle can release a chemical solution when threatened. Glands in the beetle produce hydrogen peroxide and hydroquinone, $\text{C}_6\text{H}_4(\text{OH})_2(\text{aq})$, which are combined to produce the reaction represented by the overall equation below.



The equations listed below represent reactions that are related to the production of the chemical solution.

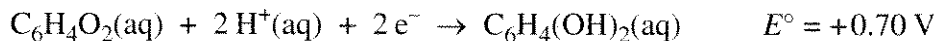
Equations



7. The enthalpy change for the overall equation is

- A. +83.0 kJ
- B. -202.6 kJ
- C. -299.4 kJ
- D. -585.0 kJ

Use the following additional information to answer the next question.

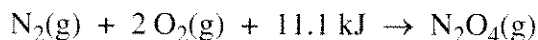
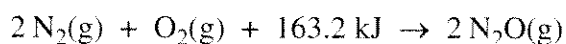
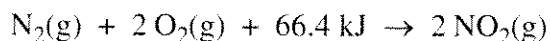
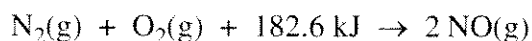


8. Which of the following substances would oxidize $\text{C}_6\text{H}_4(\text{OH})_2(\text{aq})$?

- A. $\text{Ag}^+(\text{aq})$
- B. $\text{Cu}^{2+}(\text{aq})$
- C. $\text{Ag}(\text{s})$
- D. $\text{Cu}(\text{s})$

Use the following information to answer the next two questions.

Nitrogen can react with oxygen to form a variety of oxides as represented by the following equations.



Numerical Response

2. The oxidation number of nitrogen in

NO(g) is _____ (Record in the **first** column)

NO₂(g) is _____ (Record in the **second** column)

N₂O(g) is _____ (Record in the **third** column)

N₂O₄(g) is _____ (Record in the **fourth** column)

(Record your answer in the numerical-response section on the answer sheet.)

Use the following additional information to answer the next question.

1 NO(g)

3 N₂O(g)

2 NO₂(g)

4 N₂O₄(g)

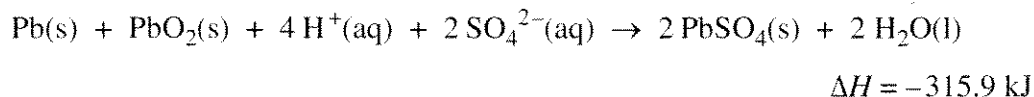
Numerical Response

3. The nitrogen oxides, listed in order of increasing enthalpy of formation, are _____, _____, _____, and _____.

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Use the following information to answer the next three questions.

The energy from a car battery is generated as represented by the equation below.



9. If 15.0 g of Pb(s) reacts in a car battery, the amount of energy released is
- A. 4.74 MJ
 - B. 4.36 MJ
 - C. 22.9 kJ
 - D. 21.1 kJ
10. During the operation of a car battery, which of the following observations can be made?
- A. The amount of Pb(s) increases as PbO₂(s) is reduced.
 - B. The amount of PbO₂(s) increases as Pb(s) is reduced.
 - C. The amount of PbO₂(s) decreases as Pb(s) is oxidized.
 - D. The amount of Pb(s) decreases as PbO₂(s) is oxidized.

Use the following additional information to answer the next question.

Every car battery is given a CCA (cold cranking amps) rating. A CCA rating of 600 means that the battery is capable of generating 600 A of current for a 30.0 s period at 0 °C.

11. Which of the following values indicates how many coulombs a battery with a CCA rating of 600 produces during 30.0 s of operation?
- A. 20.0 C
 - B. 600 C
 - C. $1.80 \times 10^4 \text{ C}$
 - D. $1.74 \times 10^9 \text{ C}$

Use the following information to answer the next two questions.

The electrolysis of aluminium oxide in an electrolytic cell occurs at high temperatures so that the compound is molten.

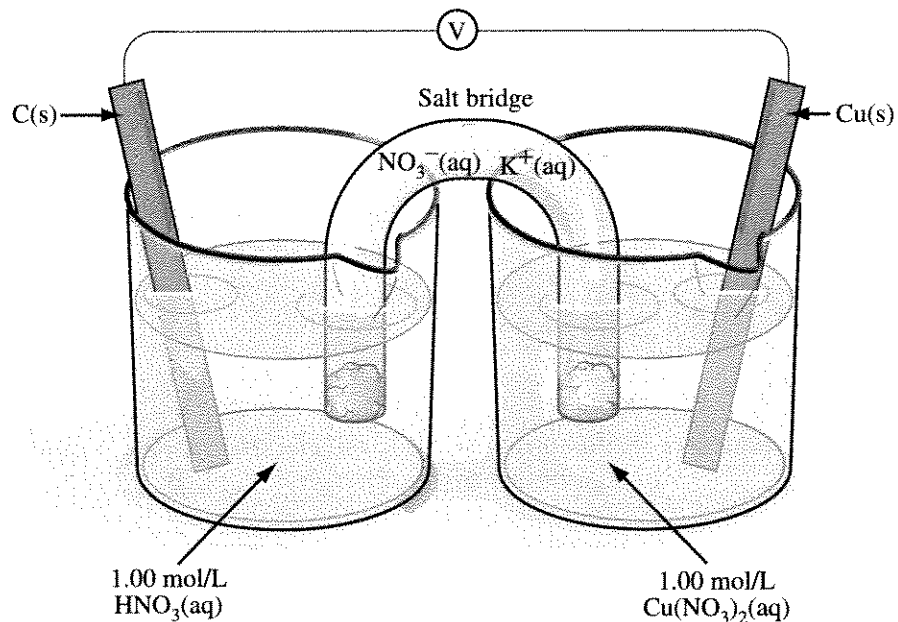
12. Which of the following equations represents the reduction half-reaction when molten aluminium oxide undergoes electrolysis?
- A. $\text{Al}^{3+}(\text{l}) \rightarrow \text{Al}(\text{l}) + 3 \text{e}^-$
- B. $\text{Al}^{3+}(\text{l}) + 3 \text{e}^- \rightarrow \text{Al}(\text{l})$
- C. $2 \text{O}^{2-}(\text{l}) \rightarrow \text{O}_2(\text{g}) + 4 \text{e}^-$
- D. $2 \text{O}^{2-}(\text{l}) + 4 \text{e}^- \rightarrow \text{O}_2(\text{g})$
13. During the production of aluminium metal in the electrolytic cell, anions travel toward the *i* and electrons travel through the *ii* .

The statement above is completed by the information in row

Row	<i>i</i>	<i>ii</i>
A.	cathode	electrolyte to the anode
B.	cathode	wire to the cathode
C.	anode	electrolyte to the anode
D.	anode	wire to the cathode

Use the following information to answer the next question.

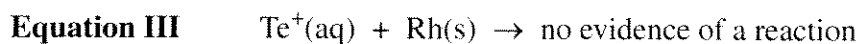
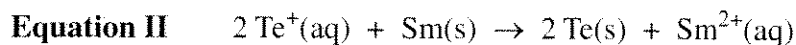
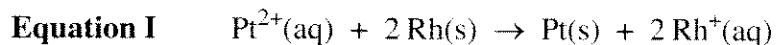
A student constructs the following standard electrochemical cell in a laboratory at 25.0 °C.



14. If the standard lead reduction half-reaction had been chosen as the reference half-reaction instead of the hydrogen reduction half-reaction, then the electrical potential for this cell would be
- A. +1.14 V
 - B. +0.93 V
 - C. +0.67 V
 - D. +0.46 V

Use the following information to answer the next two questions.

In an experiment to study the reactivity of Pt(s), Rh(s), Sm(s), and Te(s), a student observed the reactions represented by the equations below.



15. Which of the following substances is the strongest reducing agent?
- A. Pt(s)
 - B. Rh(s)
 - C. Sm(s)
 - D. Te(s)
16. Which of the following equations represents a spontaneous reaction?
- A. $\text{Te}^{+}(\text{aq}) + \text{Rh}(\text{s}) \rightarrow \text{Te}(\text{s}) + \text{Rh}^{+}(\text{aq})$
 - B. $\text{Sm}^{2+}(\text{aq}) + \text{Pt}(\text{s}) \rightarrow \text{Sm}(\text{s}) + \text{Pt}^{2+}(\text{aq})$
 - C. $\text{Pt}^{2+}(\text{aq}) + 2 \text{Te}(\text{s}) \rightarrow \text{Pt}(\text{s}) + 2 \text{Te}^{+}(\text{aq})$
 - D. $\text{Sm}^{2+}(\text{aq}) + 2 \text{Rh}(\text{s}) \rightarrow \text{Sm}(\text{s}) + 2 \text{Rh}^{+}(\text{aq})$

Use the following information to answer the next two questions.

A student placed a large piece of zinc into a beaker of hydrochloric acid and collected all of the gas produced. Indicators were also added to monitor the change in pH.

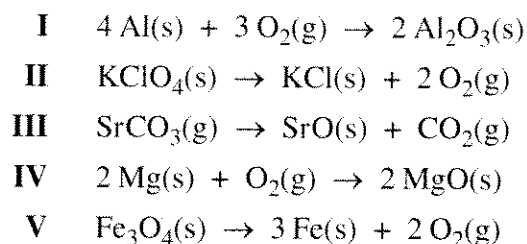
17. Which of the following rows gives the composition of the bubbles and the process through which they were formed?

Row	Composition	Process of Formation
A.	$\text{Cl}_2(\text{g})$	oxidation of chloride ions
B.	$\text{H}_2(\text{g})$	reduction of hydrogen ions
C.	$\text{H}_2(\text{g})$	reduction of water
D.	$\text{O}_2(\text{g})$	oxidation of water

18. If a student were to build a voltaic cell using solid zinc and hydrochloric acid, which of the following equipment would also be needed?
- A. An inert electrode for the cathode and a salt bridge
 - B. An inert electrode for the cathode and a power source
 - C. An inert electrode for the anode and a salt bridge
 - D. An inert electrode for the anode and a power source

Use the following information to answer the next question.

Fireworks usually contain a mixture of explosives and other chemicals. Some of the reactions that occur in a fireworks display are represented by the equations below.

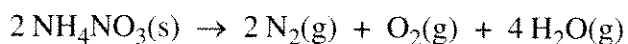


19. The equations above that represent a reaction in which the metal is being oxidized are
- A. I and IV only
 - B. II and III only
 - C. I, III, and IV
 - D. II, III, and V
-

Use the following information to answer the next question.

Ammonium nitrate, used to make gunpowder and fireworks, was extracted from animal manure in ancient China. During the explosion of gunpowder or fireworks, the ammonium nitrate reacts violently, as represented by the equation below.

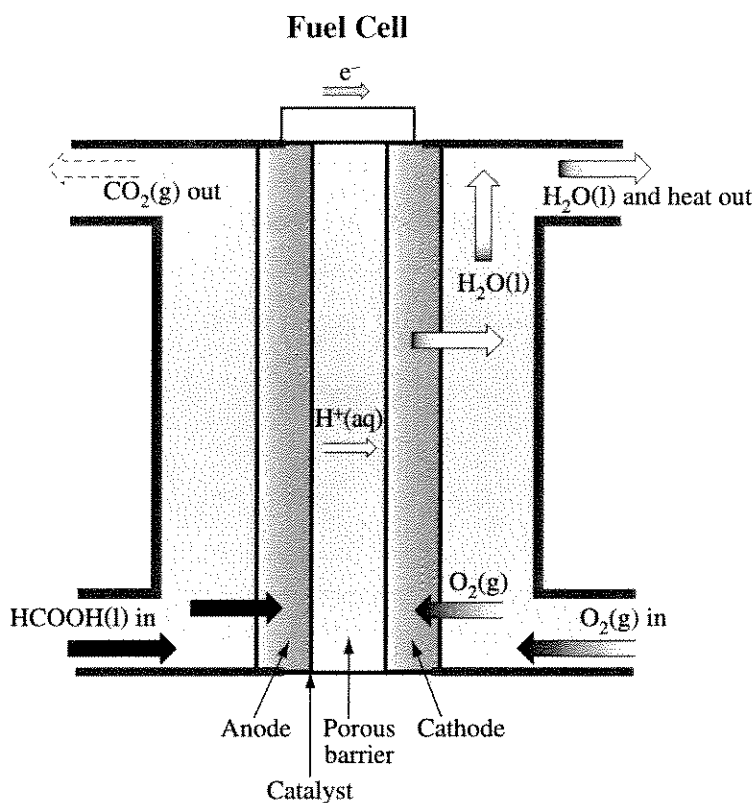
Explosion of Ammonium Nitrate



20. During the explosion of ammonium nitrate, hydrogen
- A. is oxidized
 - B. loses electrons
 - C. is the oxidizing agent
 - D. has no change in oxidation number

Use the following information to answer the next question.

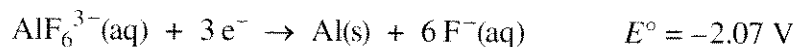
Methanoic acid, in the presence of a catalyst, can be used to produce electricity in a fuel cell, as represented by the following diagram.



21. The equation that represents the half-reaction that occurs at the cathode of the fuel cell is
- A. $\text{O}_2\text{(g)} + 4 \text{H}^+\text{(aq)} + 4 \text{e}^- \rightarrow 2 \text{H}_2\text{O(l)}$
 - B. $2 \text{H}_2\text{O(l)} \rightarrow \text{O}_2\text{(aq)} + 4 \text{H}^+\text{(aq)} + 4 \text{e}^-$
 - C. $\text{HCOOH(l)} \rightarrow \text{CO}_2\text{(aq)} + 2 \text{H}^+\text{(aq)} + 2 \text{e}^-$
 - D. $\text{CO}_2\text{(aq)} + 2 \text{H}^+\text{(aq)} + 2 \text{e}^- \rightarrow \text{HCOOH(l)}$

Use the following information to answer the next question.

The equation below represents the $\text{AlF}_6^{3-}(\text{aq})$ reduction half-reaction.



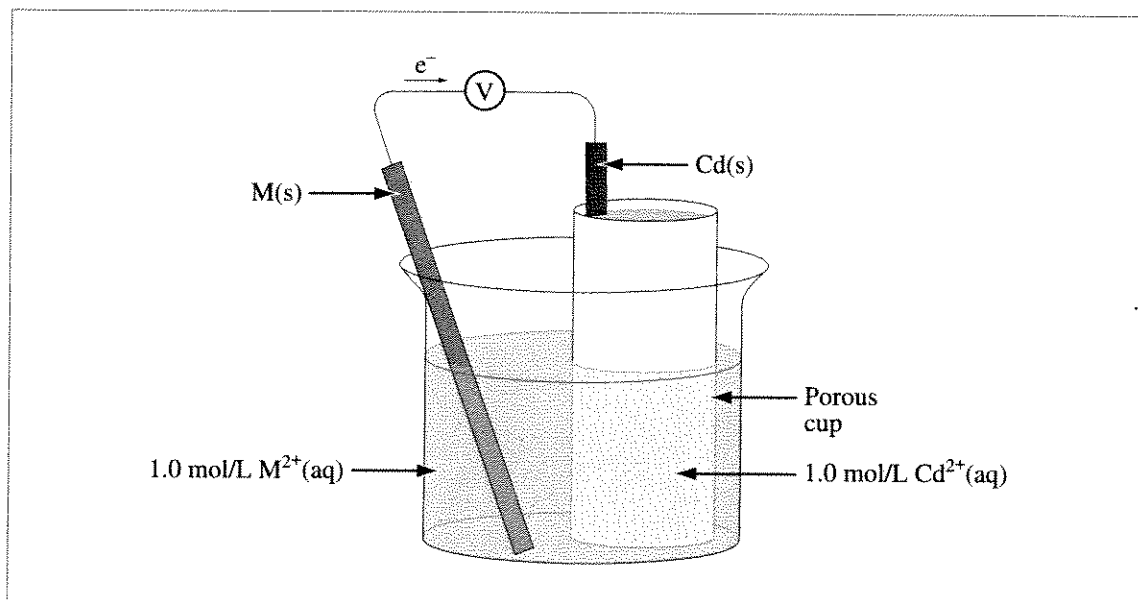
One half-cell in an electrochemical cell contains $\text{Al}(\text{s})$ in a $\text{F}^-(\text{aq})$ solution. The other half-cell contains $\text{Pb}(\text{s})$ in a $\text{Pb}^{2+}(\text{aq})$ solution. A spontaneous reaction occurs, producing $\text{AlF}_6^{3-}(\text{aq})$ and $\text{Pb}(\text{s})$.

Numerical Response

4. The net cell potential for this electrochemical cell is \pm _____ V.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.



22. If the electrochemical cell in the diagram above produces a flow of electrons in the direction indicated, then $\text{M}(\text{s})$ and $\text{M}^{2+}(\text{aq})$ could be
- A. $\text{Fe}(\text{s})$ and $\text{Fe}^{2+}(\text{aq})$
 - B. $\text{Pb}(\text{s})$ and $\text{Pb}^{2+}(\text{aq})$
 - C. $\text{Ni}(\text{s})$ and $\text{Ni}^{2+}(\text{aq})$
 - D. $\text{Cu}(\text{s})$ and $\text{Cu}^{2+}(\text{aq})$

Use the following information to answer the next two questions.

Statements About Electrochemical Cells

- I** The reaction is spontaneous.
- II** The reaction is nonspontaneous.
- III** Anions migrate to the anode.
- IV** Cations migrate to the anode.
- V** Electrons are gained at the anode.
- VI** Electrons are gained at the cathode.

- 23.** The statements above that correctly describe an electrolytic cell are
- A.** I, III, and V
 - B.** I, IV, and VI
 - C.** II, III, and VI
 - D.** II, IV, and V
- 24.** The statements above that correctly describe both an electrolytic cell and a voltaic cell are
- A.** I and III
 - B.** III and VI
 - C.** IV and V
 - D.** IV and VI

Use the following information to answer the next question.

Iron metal reacts with hydrochloric acid slowly. The equation for this reaction is

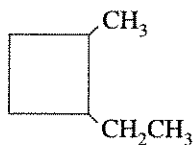


25. In this reaction, the reducing agent is

- A. $\text{FeCl}_2\text{(aq)}$
- B. HCl(aq)
- C. $\text{H}_2\text{(g)}$
- D. Fe(s)

Use the following information to answer the next question.

A student drew the structural diagram shown below.



26. The IUPAC name for the structural diagram the student drew is 1- i -2- ii .

The statement above is completed by the information in row

Row	<i>i</i>	<i>ii</i>
A.	methyl	ethylbutane
B.	methyl	ethylcyclobutane
C.	ethyl	methylbutane
D.	ethyl	methylcyclobutane

Use the following information to answer the next question.

Organic Compounds

- | | | | |
|----------|------------------------|----------|--------------------|
| 1 | 2-methylcyclobut-1-ene | 4 | 5-methylhept-3-yne |
| 2 | 1,2-dibromohexane | 5 | cycloheptane |
| 3 | 2,2-dimethylpentane | 6 | pentan-1-ol |

Numerical Response

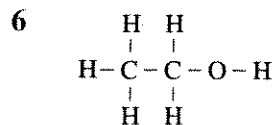
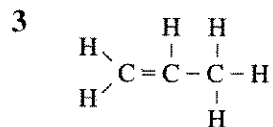
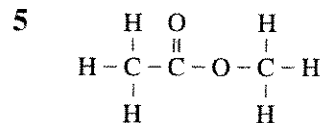
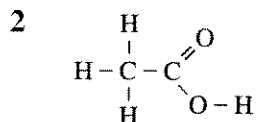
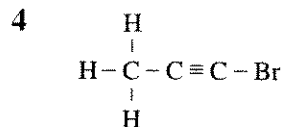
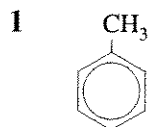
- 5.** The organic compound numbered above that

is an alkene is _____ (Record in the **first** column)
is an alcohol is _____ (Record in the **second** column)
contains a triple bond is _____ (Record in the **third** column)
is cyclic and saturated is _____ (Record in the **fourth** column)

(Record your answer in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.

Organic Compounds



Numerical Response

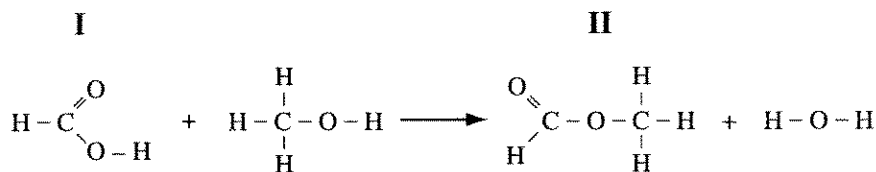
6. Match four of the organic compounds numbered above with their classifications below.

Alkyne _____ (Record in the **first** column)
Alcohol _____ (Record in the **second** column)
Aromatic _____ (Record in the **third** column)
Unsaturated hydrocarbon _____ (Record in the **fourth** column)

(Record your answer in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.

Reaction Equation



Names and Terms

- | | | | |
|---|-------------------|---|----------------|
| 1 | Methane | 6 | Ester |
| 2 | Methanol | 7 | Polymer |
| 3 | Ethanoate | 8 | Esterification |
| 4 | Methanoic acid | 9 | Polymerization |
| 5 | Methyl methanoate | | |

Numerical Response

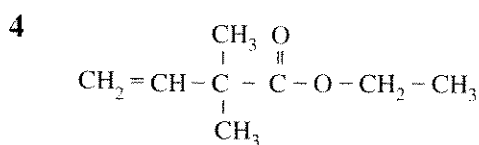
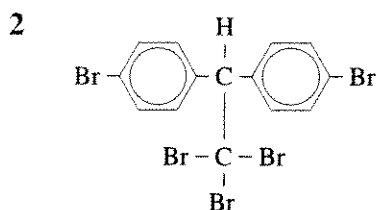
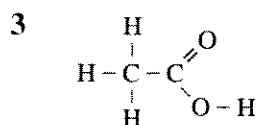
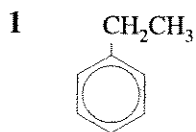
7. Match a name or a term from the list above with each descriptor given below.

Name of reactant **I** _____ (Record in the **first** column)
Name of product **II** _____ (Record in the **second** column)
Type of reaction _____ (Record in the **third** column)
Classification of product **II** _____ (Record in the **fourth** column)

(Record your answer in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.

The following are structural diagrams for four organic compounds with common industrial uses.



Numerical Response

8. Match each of the structural diagrams above with its classification below.

Aromatic _____ (Record in the **first** column)
Carboxylic acid _____ (Record in the **second** column)
Unsaturated and aliphatic _____ (Record in the **third** column)
Halogenated hydrocarbon _____ (Record in the **fourth** column)

(Record your answer in the numerical-response section on the answer sheet.)

Use the following information to answer the next two questions.

Hexane and hex-1-ene are both colourless liquids. One method used to differentiate between hexane and hex-1-ene is to add a few drops of orange-coloured aqueous bromine to samples of each organic compound.

27. Hexane is *i* hydrocarbon, and hex-1-ene is *ii* hydrocarbon.

The statement above is completed by the information in row

Row	<i>i</i>	<i>ii</i>
A.	a saturated	a saturated
B.	a saturated	an unsaturated
C.	an unsaturated	a saturated
D.	an unsaturated	an unsaturated

28. When aqueous bromine is added to hexane and hex-1-ene in the presence of light, the hexane undergoes *i* reaction and the hex-1-ene undergoes *ii* reaction.

The statement above is completed by the information in row

Row	<i>i</i>	<i>ii</i>
A.	an addition	a substitution
B.	an addition	an addition
C.	a substitution	a substitution
D.	a substitution	an addition

Use the following information to answer the next question.

Carbon-Containing Compounds

1	$\text{CCl}_4(\text{l})$	5	$\text{CO}(\text{g})$
2	$\text{Fe}_3\text{C}(\text{s})$	6	$\text{C}_3\text{H}_8(\text{g})$
3	$\text{C}_2\text{H}_2(\text{g})$	7	$\text{NaCN}(\text{s})$
4	$\text{C}_2\text{H}_5\text{OH}(\text{l})$	8	$\text{MgCO}_3(\text{s})$

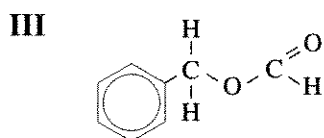
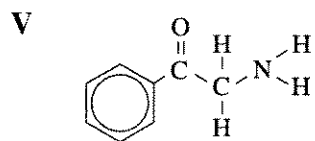
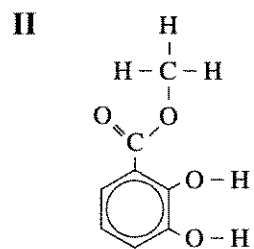
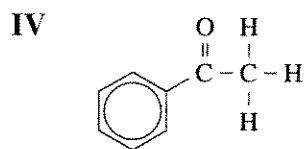
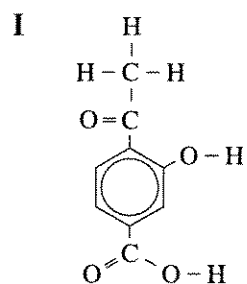
Numerical Response

- 9.** The compounds numbered above that can be classified as organic are _____, _____, _____, and _____.

(Record all **four digits** of your answer in **lowest-to-highest numerical order** in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.

Organic Compounds

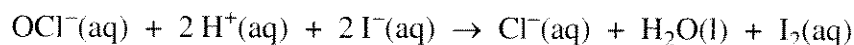


29. An ester functional group is found in

- A. II and III only
- B. II, III, and IV
- C. III only
- D. V only

Use the following information to answer the next two questions.

The concentration of aqueous sodium hypochlorite, NaOCl(aq) , in laundry bleach can be determined by titrating a sample of laundry bleach with an iodide solution, as represented by the equation below.



Numerical Response

10. If a student uses 4.25 mL of a 0.0473 mol/L $\text{I}^-(\text{aq})$ solution to titrate a 100.00 mL sample of laundry bleach, then the concentration of $\text{OCl}^-(\text{aq})$ in the laundry bleach is _____ mmol/L.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

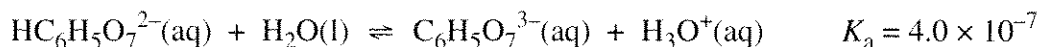
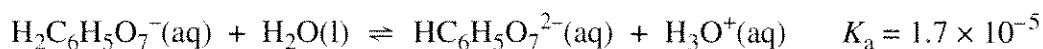
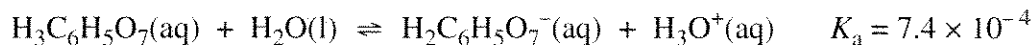
30. The K_b of $\text{OCl}^-(\text{aq})$ is *i* , and $\text{OCl}^-(\text{aq})$ is a weaker base than *ii* .

The statement above is completed by the information in row

Row	<i>i</i>	<i>ii</i>
A.	2.5×10^{-7}	$\text{PO}_4^{3-}(\text{aq})$
B.	2.5×10^{-7}	$\text{CH}_3\text{COO}^-(\text{aq})$
C.	4.0×10^{-8}	$\text{PO}_4^{3-}(\text{aq})$
D.	4.0×10^{-8}	$\text{CH}_3\text{COO}^-(\text{aq})$

Use the following information to answer the next two questions.

Citric acid, $\text{H}_3\text{C}_6\text{H}_5\text{O}_7(\text{aq})$, is a weak, polyprotic acid that is found in fruits such as oranges and lemons. Citric acid reacts with water, as represented by the following Brønsted–Lowry equations.



31. The amphiprotic species in the equations above are
- A. $\text{H}_3\text{C}_6\text{H}_5\text{O}_7(\text{aq})$, $\text{HC}_6\text{H}_5\text{O}_7^{2-}(\text{aq})$, and $\text{H}_2\text{O}(\text{l})$
 - B. $\text{H}_2\text{C}_6\text{H}_5\text{O}_7^-(\text{aq})$, $\text{HC}_6\text{H}_5\text{O}_7^{2-}(\text{aq})$, and $\text{H}_2\text{O}(\text{l})$
 - C. $\text{H}_3\text{C}_6\text{H}_5\text{O}_7(\text{aq})$ and $\text{H}_2\text{C}_6\text{H}_5\text{O}_7^-(\text{aq})$
 - D. $\text{HC}_6\text{H}_5\text{O}_7^{2-}(\text{aq})$ and $\text{C}_6\text{H}_5\text{O}_7^{3-}(\text{aq})$
32. Which of the following statements about K_a and K_b values applies to the equations above?
- A. The K_a of $\text{H}_3\text{C}_6\text{H}_5\text{O}_7(\text{aq})$ is less than the K_b of $\text{HC}_6\text{H}_5\text{O}_7^{2-}(\text{aq})$.
 - B. The K_b of $\text{HC}_6\text{H}_5\text{O}_7^{2-}(\text{aq})$ is greater than the K_b of $\text{C}_6\text{H}_5\text{O}_7^{3-}(\text{aq})$.
 - C. The K_a of $\text{H}_2\text{C}_6\text{H}_5\text{O}_7^-(\text{aq})$ is greater than the K_b of $\text{C}_6\text{H}_5\text{O}_7^{3-}(\text{aq})$.
 - D. The K_b of $\text{H}_2\text{C}_6\text{H}_5\text{O}_7^-(\text{aq})$ is greater than the K_b of $\text{HC}_6\text{H}_5\text{O}_7^{2-}(\text{aq})$.

Use the following information to answer the next two questions.

Lactic acid, $\text{HC}_3\text{H}_5\text{O}_3(\text{aq})$, is produced in human muscle cells when not enough oxygen is supplied to the muscle during heavy physical activity. The equation below represents the Brønsted–Lowry reaction of lactic acid and water.



33. Which of the following rows identifies the Brønsted–Lowry acids and a conjugate acid–base pair in the equation above?

Row	Brønsted–Lowry Acids	Conjugate Acid–Base Pair
A.	$\text{HC}_3\text{H}_5\text{O}_3(\text{aq})$ and $\text{C}_3\text{H}_5\text{O}_3^-(\text{aq})$	$\text{H}_2\text{O}(\text{l})$ and $\text{H}_3\text{O}^+(\text{aq})$
B.	$\text{HC}_3\text{H}_5\text{O}_3(\text{aq})$ and $\text{C}_3\text{H}_5\text{O}_3^-(\text{aq})$	$\text{C}_3\text{H}_5\text{O}_3^-(\text{aq})$ and $\text{H}_3\text{O}^+(\text{aq})$
C.	$\text{HC}_3\text{H}_5\text{O}_3(\text{aq})$ and $\text{H}_3\text{O}^+(\text{aq})$	$\text{H}_2\text{O}(\text{l})$ and $\text{H}_3\text{O}^+(\text{aq})$
D.	$\text{HC}_3\text{H}_5\text{O}_3(\text{aq})$ and $\text{H}_3\text{O}^+(\text{aq})$	$\text{C}_3\text{H}_5\text{O}_3^-(\text{aq})$ and $\text{H}_3\text{O}^+(\text{aq})$

Use the following additional information to answer the next question.

A 100.0 mL sample of lactic acid has a pH of 3.38.

Numerical Response

11. The hydroxide ion concentration in this sample of lactic acid, expressed in scientific notation, is $a.b \times 10^{-cd}$ mol/L. The values of a , b , c , and d are _____, _____, _____, and _____.

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

34. If a 100.0 mL sample of 0.167 mol/L unknown acid has a pH of 2.32 at 25.0 °C, then the K_a is
- A. 2.9×10^{-2}
B. 4.8×10^{-3}
C. 1.4×10^{-4}
D. 2.3×10^{-5}

Use the following information to answer the next question.

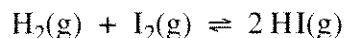
A technician placed an amount of the colourless gas dinitrogen tetraoxide into a flask. He closed the flask and allowed the reaction to reach equilibrium. The dinitrogen tetraoxide partially decomposed to form brown-coloured nitrogen dioxide gas. The data collected during the experiment were recorded below.

	$\text{N}_2\text{O}_4(\text{g})$	$\text{NO}_2(\text{g})$
Initial Concentration (mol/L)	0.700	0.000
Final Concentration (mol/L)	0.610	0.180

35. The balanced chemical equation and equilibrium constant for the partial decomposition of dinitrogen tetraoxide gas are
- A. $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons \text{NO}_2(\text{g}) \quad K_c = 0.295$
- B. $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2 \text{NO}_2(\text{g}) \quad K_c = 0.053 \text{ l}$
- C. $\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g}) \quad K_c = 3.39$
- D. $2 \text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g}) \quad K_c = 18.8$

Use the following information to answer the next question.

When the system represented by the equation below is at equilibrium in a 2.00 L flask at 15.0 °C, the flask contains 1.15 mmol of $\text{H}_2(\text{g})$, 2.13 mmol of $\text{I}_2(\text{g})$, and 3.74 mmol of $\text{HI}(\text{g})$.



Numerical Response

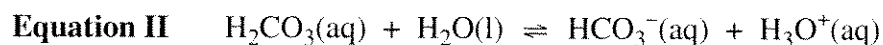
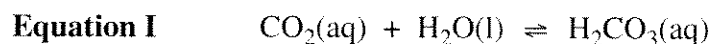
12. At 15.0 °C, the equilibrium constant is _____.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

Use the following information to answer the next two questions.

In blood, the enzyme carbonic anhydrase catalyzes the formation of carbonic acid from aqueous carbon dioxide and water. Carbonic acid and hydrogen carbonate form an important buffer in the blood. Two reactions that occur in the blood are represented by the equations below.

Reactions in the Blood



36. If the concentration of $\text{CO}_2(\text{aq})$ in the blood increases, then the equilibria will shift to the *i* , and the concentration of $\text{HCO}_3^-(\text{aq})$ in the blood will *ii* .

The statement above is completed by the information in row

Row	<i>i</i>	<i>ii</i>
A.	left	increase
B.	left	decrease
C.	right	increase
D.	right	decrease

37. The equilibrium law expression for the reaction represented by equation II is

A. $K_c = \frac{[\text{H}_2\text{CO}_3(\text{aq})][\text{H}_2\text{O}(\text{l})]}{[\text{HCO}_3^-(\text{aq})][\text{H}_3\text{O}^+(\text{aq})]}$

B. $K_c = \frac{[\text{H}_2\text{CO}_3(\text{aq})]}{[\text{HCO}_3^-(\text{aq})][\text{H}_3\text{O}^+(\text{aq})]}$

C. $K_c = \frac{[\text{HCO}_3^-(\text{aq})][\text{H}_3\text{O}^+(\text{aq})]}{[\text{H}_2\text{CO}_3(\text{aq})][\text{H}_2\text{O}(\text{l})]}$

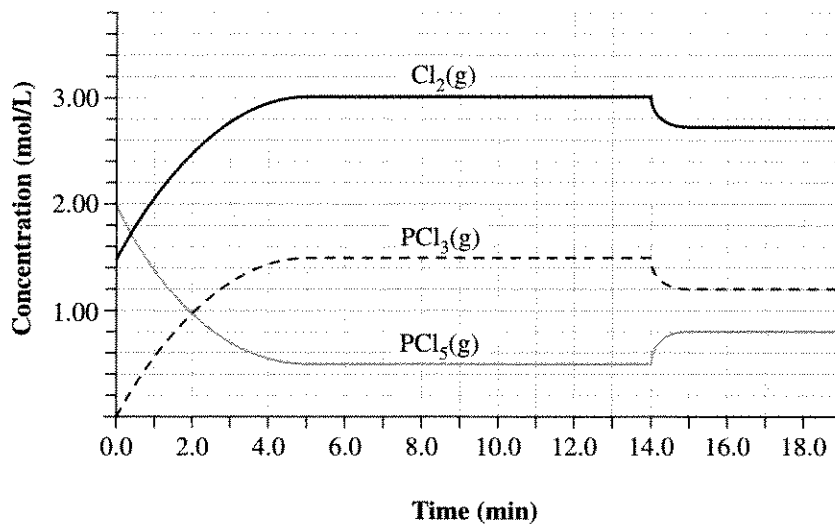
D. $K_c = \frac{[\text{HCO}_3^-(\text{aq})][\text{H}_3\text{O}^+(\text{aq})]}{[\text{H}_2\text{CO}_3(\text{aq})]}$

Use the following information to answer the next question.

At 200 °C, the equilibrium system represented by the following equation and diagram was established.



Equilibrium System



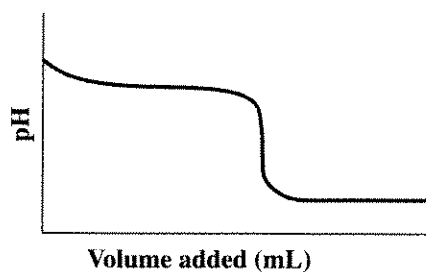
38. In the equilibrium system represented in the diagram above, equilibrium was initially established at *i* , and the stress applied to the system at 14.0 minutes was *ii* in temperature.

The statement above is completed by the information in row

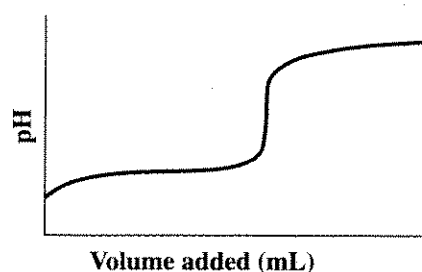
Row	<i>i</i>	<i>ii</i>
A.	4.5 min	an increase
B.	4.5 min	a decrease
C.	14.0 min	an increase
D.	14.0 min	a decrease

39. Which of the following graphs represents the titration of a weak, polyprotic base with a strong, monoprotic acid?

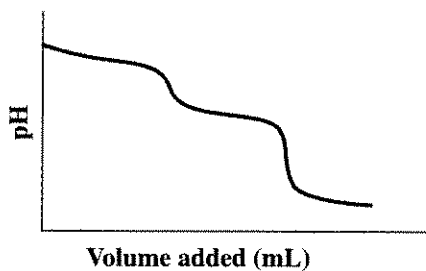
A.



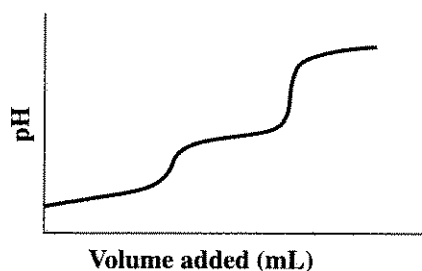
B.



C.



D.



40. Which of the following systems could be at equilibrium?

- A. A closed bottle of carbonated water
- B. A block of ice in a glass of water
- C. Water boiling in a kettle
- D. A glass of pop

Use the following information to answer the next question.

	Equations	K_c at 25 °C
1	$\text{H}_2(\text{g}) + \text{Br}_2(\text{g}) \rightleftharpoons 2 \text{HBr}(\text{g})$	5.0×10^{-18}
2	$\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons 2 \text{HCl}(\text{g})$	2.5×10^{33}
3	$\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2 \text{NO}(\text{g})$	2.0×10^{-31}
4	$\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2 \text{HI}(\text{g})$	2.5×10^{-1}

Numerical Response

13. When the equations numbered above are ordered from the reaction that produces the **most** products to the reaction that produces the **least** products, the order is

_____, _____, _____, and _____.
Most **Least**

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.

	Weak Acids
1	$\text{HF}(\text{aq})$
2	$\text{H}_2\text{S}(\text{aq})$
3	$\text{HOCl}(\text{aq})$
4	$\text{H}_2\text{SO}_3(\text{aq})$

Numerical Response

14. When the weak acids numbered above are ordered from the acid with the **strongest** conjugate base to the acid with the **weakest** conjugate base, the order is

_____, _____, _____, and _____.
Strongest **Weakest**

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.

Pairs of Solutions

- I** HCl(aq) and NaOH(aq)
- II** $\text{HClO}_4\text{(aq)}$ and $\text{KClO}_4\text{(aq)}$
- III** $\text{H}_2\text{SO}_4\text{(aq)}$ and $\text{LiHSO}_4\text{(aq)}$
- IV** $\text{H}_3\text{PO}_4\text{(aq)}$ and $\text{NaH}_2\text{PO}_4\text{(aq)}$

- 41.** If each pair of solutions listed above is mixed together in equal amounts, then the pair of solutions that would act as a buffer is
- A.** I
 - B.** II
 - C.** III
 - D.** IV

Chemistry 30 Diploma Examination January 2009,
Part A: Written-Response Questions

Use the following information to answer the first question.

Sour gas contains a significant amount of hydrogen sulfide gas mixed with methane gas. Hydrogen sulfide gas is a colourless, toxic gas that smells like rotten eggs. Hydrogen sulfide gas can be converted to sulfur dioxide gas in a process called flaring, as represented by the equation below.



Written Response—10%

1.
 - a. **Determine** the enthalpy change for the flaring process represented by the equation above. (3 marks)
 - b. **Sketch** and label a potential energy diagram that represents the enthalpy change for the flaring process. (2 marks)

Use the following information to answer the next question.

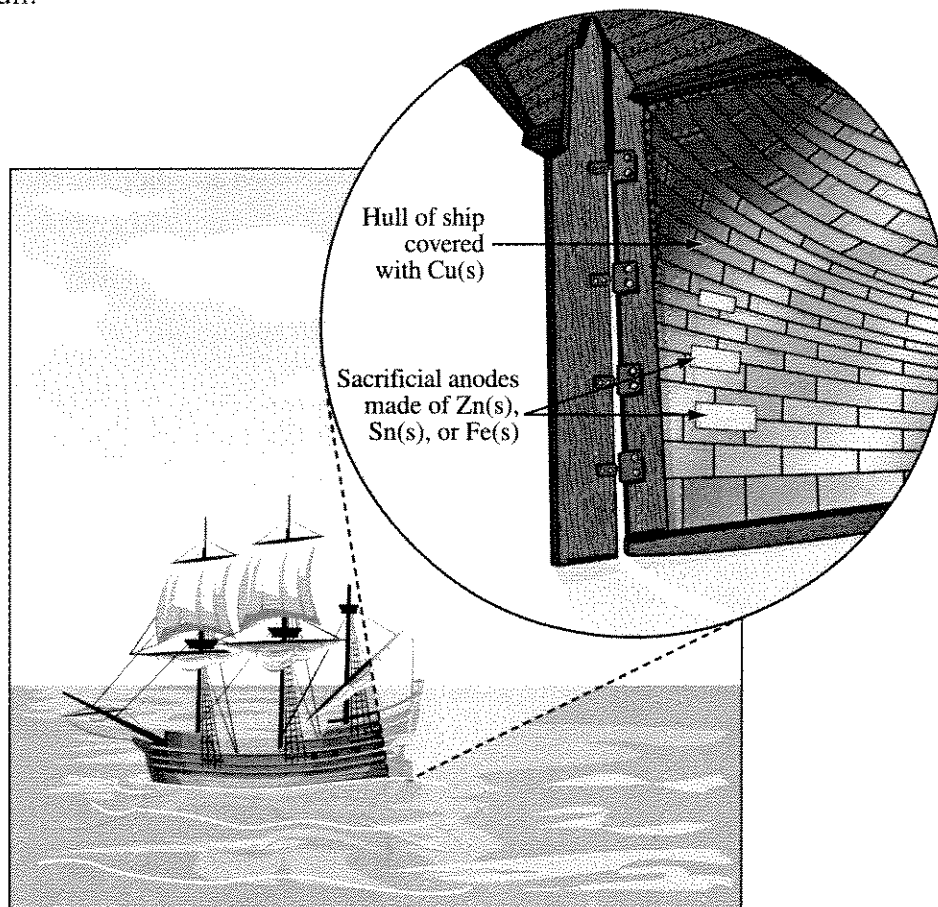
Large amounts of ammonia for the production of fertilizers and other consumer goods are made by the Haber process. During the Haber process, hydrogen gas combines with nitrogen gas to produce ammonia gas. This process is carried out in the presence of a catalyst.

Written Response—10%

2. a. Write a balanced equilibrium equation for the Haber process. Include the enthalpy change as an energy term in the balanced equation. (3 marks)
- b. Describe what happens to the equilibrium position and the value of the equilibrium constant when the temperature of the system is increased from 200 °C to 500 °C. (2 marks)

Use the following information to answer the next question.

The copper covering on the hull of a ship, which is the main body of the ship that is in contact with water, corrodes when it is exposed to water and oxygen. To protect against such corrosion on British naval ships, Sir Humphry Davy was the first to use blocks of either zinc, tin, or iron as sacrificial anodes, which were attached to the ship's hull.



Written Response—15%

3. **Explain** how a block of zinc, tin, or iron would prevent the corrosion of the copper on a ship's hull.

Your response should include

- an explanation of the corrosion of copper
- an explanation of how a block of zinc, tin, or iron protects the copper from corrosion
- relevant balanced equations and E°_{cell} calculations to support each of your explanations

***Chemistry 30 Diploma Examination January 2009,
Part B: Multiple-Choice and Numerical-Response Answers***

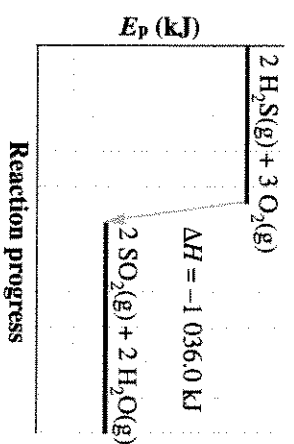
Key: MC–Multiple Choice; NR–Numerical Response

Question	Key	Diff. %	Question	Key	Diff. %
MC1	A	66.3	MC25	D	78.6
MC2	D	56.9	MC26	D	69.3
MC3	D	71.6	NR5	1645	87.4
MC4	B	68.3	NR6	4613/4614	66.1
MC5	A	67.4	NR7	4586	54.0
NR1	3435/3453/ 4335/4353	41.0	NR8	1342/2342	71.8
MC6	C	81.6	MC27	B	86.7
MC7	B	62.7	MC28	D	77.5
MC8	A	54.5	NR9	1346 (any order)	59.5
NR2	2414	78.6	MC29	A	58.4
NR3	4231	52.8	NR10	1.01	46.7
MC9	C	66.7	MC30	A	60.7
MC10	C	43.3	MC31	B	61.0
MC11	C	65.9	MC32	C	64.4
MC12	B	78.8	MC33	C	58.9
MC13	D	73.5	NR11	2411	59.6
MC14	D	63.3	MC34	C	42.7
MC15	C	70.7	MC35	B	79.8
MC16	C	76.3	NR12	5.71/5.68	54.9
MC17	B	59.6	MC36	C	76.5
MC18	A	62.9	MC37	D	78.1
MC19	A	72.5	MC38	B	73.2
MC20	D	66.9	MC39	C	55.7
MC21	A	89.2	MC40	A	81.5
NR4	1.94	55.5	NR13	2413	75.8
MC22	A	83.4	NR14	3214	76.7
MC23	C	71.9	MC41	D	46.3
MC24	B	74.2			

*Difficulty–percentage of students answering the question correctly

**Chemistry 30 Diploma Examination January 2009,
Part A: Written-Response Sample Answers**

*Please note that these are only sample responses, and that other variations of the response may also have received full marks.

Question	Marks	Sample Response – Analytic Scoring Criteria	Comments
1.a.	3	$2 \text{H}_2\text{S}(\text{g}) + 3 \text{O}_2(\text{g}) \rightarrow 2 \text{SO}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{g})$ $\Delta H^\circ = \sum n \Delta_f H^\circ_{(\text{products})} - \sum n \Delta_f H^\circ_{(\text{reactants})}$ $= [(2 \text{ mol})(-296.8 \text{ kJ/mol}) + (2 \text{ mol})(-241.8 \text{ kJ/mol})]$ $- [(2 \text{ mol})(-20.6 \text{ kJ/mol}) + (3 \text{ mol})(0 \text{ kJ/mol})]$ $= (-1\,077.2 \text{ kJ}) - (-41.2 \text{ kJ})$ $= -1\,036.0 \text{ kJ}$	<ul style="list-style-type: none"> • 1 mark for correct method • 1 mark for substitution consistent with method • 1 mark for correct answer
1.b.	2	<p>Combustion of $\text{H}_2\text{S}(\text{g})$</p> 	<ul style="list-style-type: none"> • 1 mark for correct labels • 1 mark for shape of graph consistent with calculation
	1	Communication—See Guide	Use Analytic Scoring Guide
		Total possible marks = 6	

Question	Marks	Sample Response – Analytic Scoring Criteria	Comments
2.a.	3	$3 \text{H}_2(\text{g}) + \text{N}_2(\text{g}) \rightleftharpoons 2 \text{NH}_3(\text{g}) + 91.8 \text{ kJ}$	<ul style="list-style-type: none"> • 1 mark for balanced equation • 1 mark for the correct heat value • 1 mark for the inclusion of the heat term on the correct side
2.b.	2	The equilibrium position would shift toward the reactants because the forward reaction is exothermic, and the K_c value would decrease.	<ul style="list-style-type: none"> • 1 mark for correct shift in equilibrium consistent with heat term • 1 mark for a change in K_c consistent with the shift
	1	Communication—See Guide	Use Analytic Scoring Guide
		Total possible marks = 4	

Question	Marks	Sample Response – Holistic Scoring Criteria	Comments
3.		<p>Corrosion Explanation</p> <p>The corrosion of copper is the spontaneous oxidation reaction that occurs when copper reacts with water and oxygen. Solid copper is oxidized to $\text{Cu}^{2+}(\text{aq})$.</p> $\text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + 4\text{e}^- \rightarrow 4\text{OH}^-(\text{aq}) \quad E^\circ_{\text{reduction}} = +0.40\text{ V}$ $\text{Cu}(\text{s}) \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \quad E^\circ_{\text{reduction}} = +0.34\text{ V}$ <hr/> $\text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + 2\text{Cu}(\text{s}) \rightarrow 4\text{OH}^-(\text{aq}) + 2\text{Cu}^{2+}(\text{aq}) \quad \Delta E^\circ_{\text{cell}} = +0.06\text{ V}$ $\text{OR} \rightarrow 2\text{Cu}(\text{OH})_2(\text{s})$ <p>Sacrificial Anode Explanation</p> <p>The metal found in the sacrificial anode prevents the corrosion of copper because it (Zn, Sn, or Fe) is a stronger reducing agent than copper and the metal undergoes oxidation before the copper.</p> <p>If both iron and copper are present with water and oxygen, the reaction that occurs is the following.</p> $\text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + 2\text{Fe}(\text{s}) \rightarrow 4\text{OH}^-(\text{aq}) + 2\text{Fe}^{2+}(\text{aq}) \quad \Delta E^\circ = +0.85\text{ V}$ $\text{OR} \rightarrow 2\text{Fe}(\text{OH})_2(\text{s})$	<p><i>Key Component</i></p> <ul style="list-style-type: none"> • explanation that $\text{Fe}(\text{s})$, $\text{Sn}(\text{s})$ or $\text{Zn}(\text{s})$ reacts spontaneously with the oxidizing agent before $\text{Cu}(\text{s})$ <p><i>Support</i></p> <ul style="list-style-type: none"> • explanation of the corrosion of copper • explanation of the sacrificial anode • relevant equations and E°_{cell} calculation

