Chemistry 30 | Released Items

2009 Released Diploma Examination Items

Alberta Education

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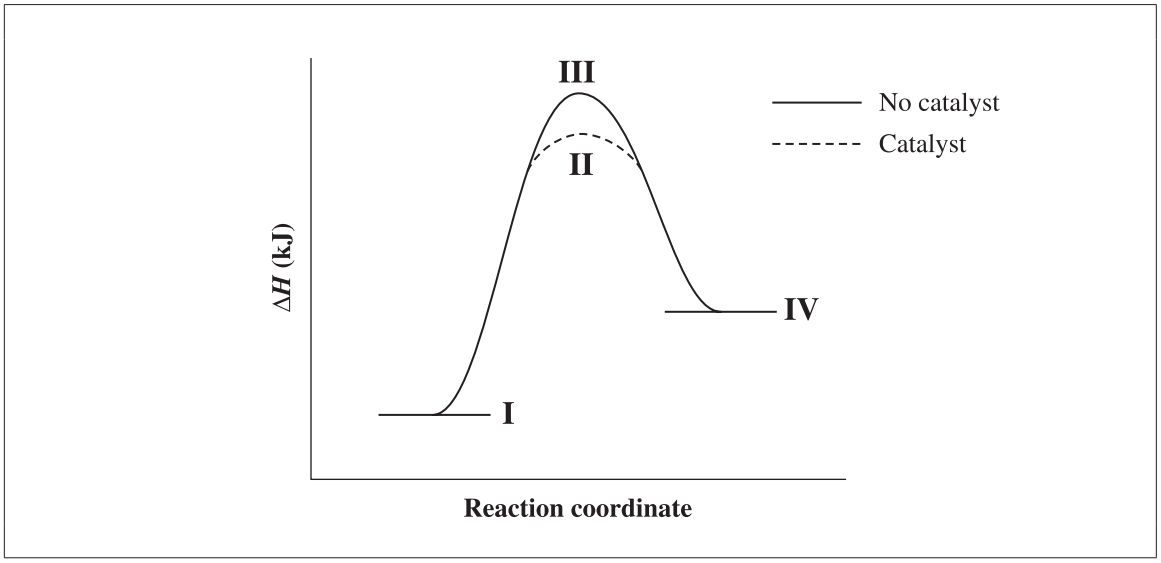
Chemistry 30 Diploma Examination January 2009, Part B: Multiple-Choice and Numerical-Response Questions

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.

$$2\,CO(g) + O_2(g) \rightleftharpoons 2\,CO_2(g)$$

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*	*ii*
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, $C_6H_{12}O_6(s)$. 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. -6.05×10^{-3} kJ/mol

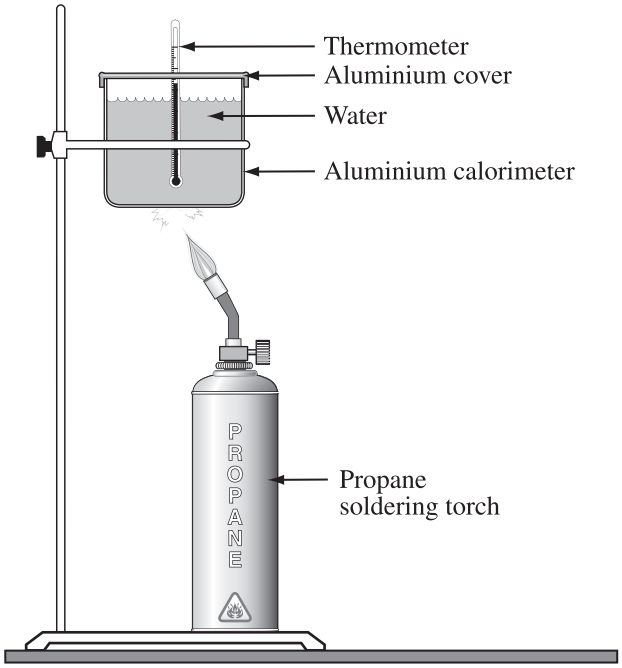
B. -9.68×10^{-2} kJ/mol

C. -4.03 kJ/mol

D. -2.69×10^{3} 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*	*ii*
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**	$H_2O(l)$
2	$CO(g)$	**5**	$H_2O(g)$
3	$CO_2(g)$	**6**	$C_6H_{12}O_6(aq)$

Numerical Response

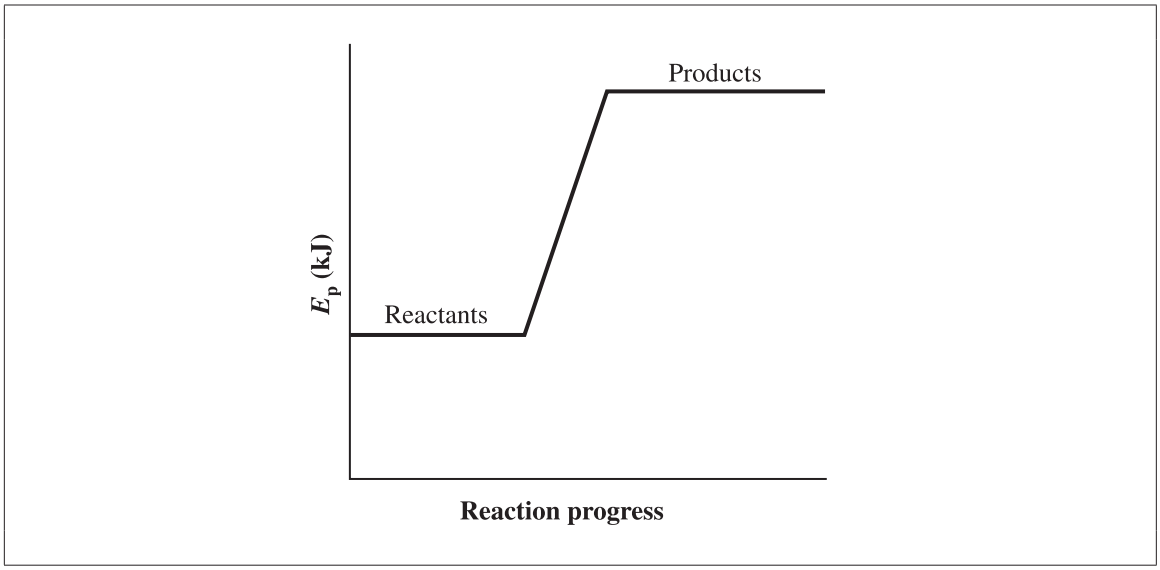
1. Match the chemicals numbered above with the statements given below.

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***	***ii***
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, $C_6H_4(OH)_2(aq)$, which are combined to produce the reaction represented by the overall equation below.

$$C_6H_4(OH)_2(aq) + H_2O_2(aq) \rightarrow C_6H_4O_2(aq) + 2\,H_2O(l)$$

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

Equations

I	$C_6H_4(OH)_2(aq) \rightarrow C_6H_4O_2(aq) + H_2(g)$	$\Delta H = +177.4$ kJ
II	$H_2(g) + O_2(g) \rightarrow H_2O_2(aq)$	$\Delta H = -191.2$ kJ
III	$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g)$	$\Delta H = -241.8$ kJ
IV	$H_2O(g) \rightarrow H_2O(l)$	$\Delta H = -43.8$ kJ

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.

$$C_6H_4O_2(aq) + 2\,H^+(aq) + 2\,e^- \rightarrow C_6H_4(OH)_2(aq) \qquad E^\circ = +0.70\text{ V}$$

8. Which of the following substances would oxidize $C_6H_4(OH)_2(aq)$?

A. $Ag^+(aq)$

B. $Cu^{2+}(aq)$

C. Ag(s)

D. Cu(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.

$$N_2(g) + O_2(g) + 182.6\ kJ \rightarrow 2\,NO(g)$$
$$N_2(g) + 2\,O_2(g) + 66.4\ kJ \rightarrow 2\,NO_2(g)$$
$$2\,N_2(g) + O_2(g) + 163.2\ kJ \rightarrow 2\,N_2O(g)$$
$$N_2(g) + 2\,O_2(g) + 11.1\ kJ \rightarrow N_2O_4(g)$$

Numerical Response

2. The oxidation number of nitrogen in

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

$NO_2(g)$ is _____ (Record in the **second** column)

$N_2O(g)$ is _____ (Record in the **third** column)

$N_2O_4(g)$ 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** $N_2O(g)$

2 $NO_2(g)$ **4** $N_2O_4(g)$

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.

$$Pb(s) + PbO_2(s) + 4\,H^+(aq) + 2\,SO_4^{2-}(aq) \rightarrow 2\,PbSO_4(s) + 2\,H_2O(l)$$

$$\Delta H = -315.9 \text{ kJ}$$

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 $PbO_2(s)$ is reduced.

B. The amount of $PbO_2(s)$ increases as Pb(s) is reduced.

C. The amount of $PbO_2(s)$ decreases as Pb(s) is oxidized.

D. The amount of Pb(s) decreases as $PbO_2(s)$ 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. 1.80×10^4 C

D. 1.74×10^9 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. $Al^{3+}(l) \rightarrow Al(l) + 3\,e^-$

B. $Al^{3+}(l) + 3\,e^- \rightarrow Al(l)$

C. $2\,O^{2-}(l) \rightarrow O_2(g) + 4\,e^-$

D. $2\,O^{2-}(l) + 4\,e^- \rightarrow O_2(g)$

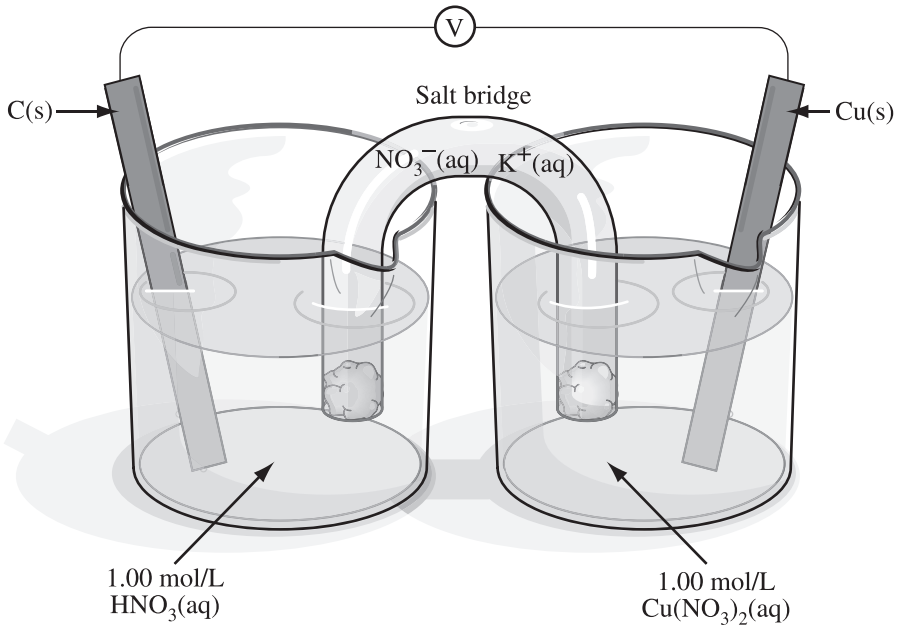
13. *During the production of aluminium metal in the electrolytic cell, anions travel toward the* ___***i***___ *and electrons travel through the* ___***ii***___ .

The statement above is completed by the information in row

Row	***i***	***ii***
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.

Equation I $Pt^{2+}(aq) + 2\,Rh(s) \rightarrow Pt(s) + 2\,Rh^{+}(aq)$

Equation II $2\,Te^{+}(aq) + Sm(s) \rightarrow 2\,Te(s) + Sm^{2+}(aq)$

Equation III $Te^{+}(aq) + Rh(s) \rightarrow$ no evidence of a reaction

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. $Te^{+}(aq) + Rh(s) \rightarrow Te(s) + Rh^{+}(aq)$

B. $Sm^{2+}(aq) + Pt(s) \rightarrow Sm(s) + Pt^{2+}(aq)$

C. $Pt^{2+}(aq) + 2\,Te(s) \rightarrow Pt(s) + 2\,Te^{+}(aq)$

D. $Sm^{2+}(aq) + 2\,Rh(s) \rightarrow Sm(s) + 2\,Rh^{+}(aq)$

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.	$Cl_2(g)$	oxidation of chloride ions
B.	$H_2(g)$	reduction of hydrogen ions
C.	$H_2(g)$	reduction of water
D.	$O_2(g)$	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.

I $4\,Al(s) + 3\,O_2(g) \rightarrow 2\,Al_2O_3(s)$

II $KClO_4(s) \rightarrow KCl(s) + 2\,O_2(g)$

III $SrCO_3(g) \rightarrow SrO(s) + CO_2(g)$

IV $2\,Mg(s) + O_2(g) \rightarrow 2\,MgO(s)$

V $Fe_3O_4(s) \rightarrow 3\,Fe(s) + 2\,O_2(g)$

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

$$2\,NH_4NO_3(s) \rightarrow 2\,N_2(g) + O_2(g) + 4\,H_2O(g)$$

20. During the explosion of ammonium nitrate, hydrogen

A. is oxidized

B. loses electrons

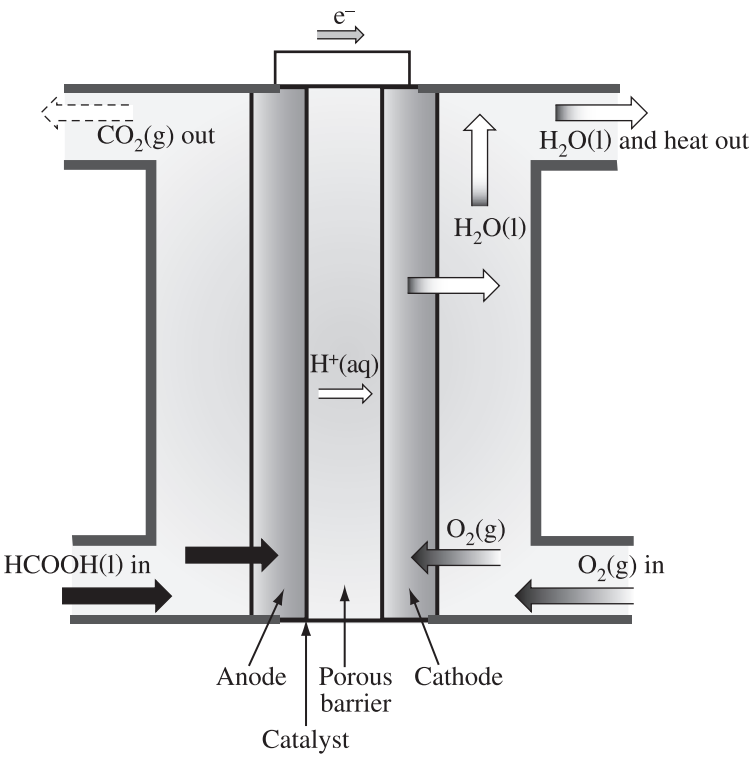
C. is the oxidizing agent

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.

Fuel Cell



21. The equation that represents the half-reaction that occurs at the cathode of the fuel cell is

A. $O_2(g) + 4\,H^+(aq) + 4\,e^- \rightarrow 2\,H_2O(l)$

B. $2\,H_2O(l) \rightarrow O_2(aq) + 4\,H^+(aq) + 4\,e^-$

C. $HCOOH(l) \rightarrow CO_2(aq) + 2\,H^+(aq) + 2\,e^-$

D. $CO_2(aq) + 2\,H^+(aq) + 2\,e^- \rightarrow HCOOH(l)$

Use the following information to answer the next question.

The equation below represents the $AlF_6^{3-}(aq)$ reduction half-reaction.

$$AlF_6^{3-}(aq) + 3\,e^- \rightarrow Al(s) + 6\,F^-(aq) \qquad E^\circ = -2.07\ V$$

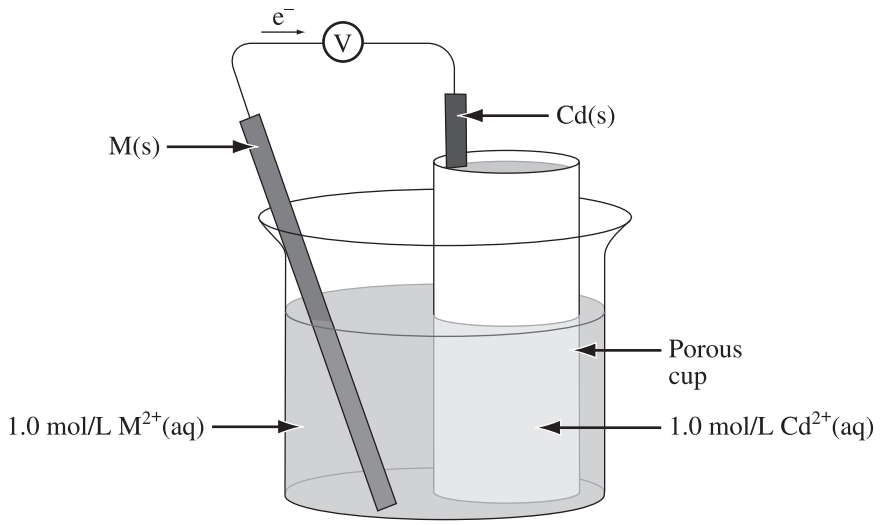
One half-cell in an electrochemical cell contains Al(s) in a $F^-(aq)$ solution. The other half-cell contains Pb(s) in a $Pb^{2+}(aq)$ solution. A spontaneous reaction occurs, producing $AlF_6^{3-}(aq)$ and Pb(s).

Numerical Response

4. The net cell potential for this electrochemical cell is +/– _____ 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 M(s) and $M^{2+}(aq)$ could be

A. Fe(s) and $Fe^{2+}(aq)$

B. Pb(s) and $Pb^{2+}(aq)$

C. Ni(s) and $Ni^{2+}(aq)$

D. Cu(s) and $Cu^{2+}(aq)$

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

$$Fe(s) + 2\,HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$$

25. In this reaction, the reducing agent is

A. $FeCl_2(aq)$

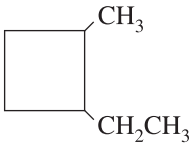
B. $HCl(aq)$

C. $H_2(g)$

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***	***ii***
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

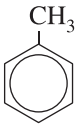
is an alkene is _____ (Record in the **first** column)
is an alcohol is _____ (Record in the **second** column)
contains a triple bond is _____ (Record in the **third** column)
is cyclic and saturated is _____ (Record in the **fourth** column)

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

Use the following information to answer the next question.

Organic Compounds

1



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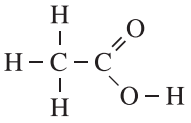

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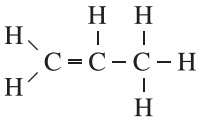

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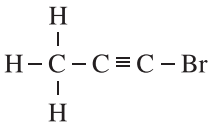

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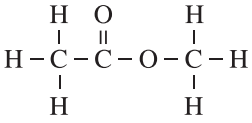
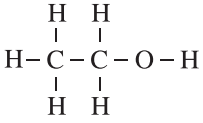


6



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)

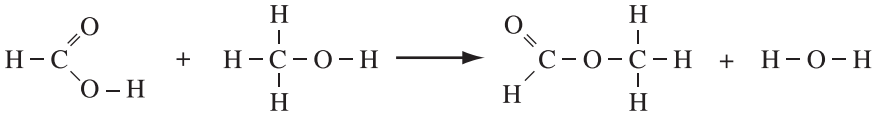
Unsaturated hydrocarbon _____ (Record in the **fourth** column)

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

Use the following information to answer the next question.

Reaction Equation

I **II**



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)

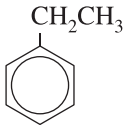
Classification of product **II** _____ (Record in the **fourth** column)

(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.

1



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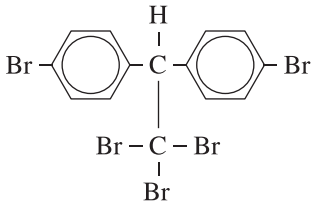

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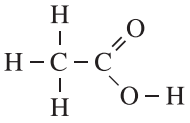

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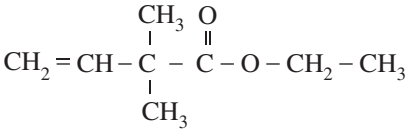


Numerical Response

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***	***ii***
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***	***ii***
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	$CCl_4(l)$	**5**	$CO(g)$
2	$Fe_3C(s)$	**6**	$C_3H_8(g)$
3	$C_2H_2(g)$	**7**	$NaCN(s)$
4	$C_2H_5OH(l)$	**8**	$MgCO_3(s)$

Numerical Response

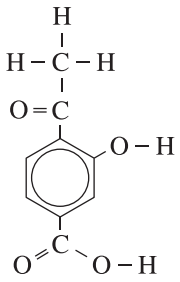
9. The compounds numbered above that can be classified as organic are _____, _____, _____, and _____.

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

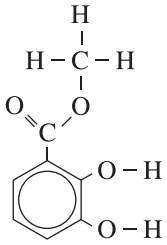
Use the following information to answer the next question.

Organic Compounds

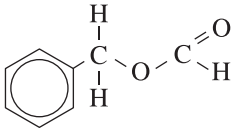
I



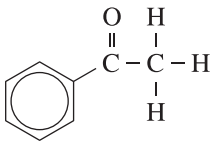
II



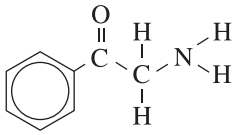
III



IV



V



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.

$$OCl^-(aq) + 2\,H^+(aq) + 2\,I^-(aq) \rightarrow Cl^-(aq) + H_2O(l) + I_2(aq)$$

Numerical Response

10. If a student uses 4.25 mL of a 0.047 3 mol/L $I^-(aq)$ solution to titrate a 100.00 mL sample of laundry bleach, then the concentration of $OCl^-(aq)$ 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 $OCl^-(aq)$ is* ___***i***___ *, and $OCl^-(aq)$ is a weaker base than* ___***ii***___ .

The statement above is completed by the information in row

Row	*i*	*ii*
A.	2.5×10^{-7}	$PO_4^{3-}(aq)$
B.	2.5×10^{-7}	$CH_3COO^-(aq)$
C.	4.0×10^{-8}	$PO_4^{3-}(aq)$
D.	4.0×10^{-8}	$CH_3COO^-(aq)$

Use the following information to answer the next two questions.

Citric acid, $H_3C_6H_5O_7(aq)$, 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.

$$H_3C_6H_5O_7(aq) + H_2O(l) \rightleftharpoons H_2C_6H_5O_7^-(aq) + H_3O^+(aq) \qquad K_a = 7.4 \times 10^{-4}$$

$$H_2C_6H_5O_7^-(aq) + H_2O(l) \rightleftharpoons HC_6H_5O_7^{2-}(aq) + H_3O^+(aq) \qquad K_a = 1.7 \times 10^{-5}$$

$$HC_6H_5O_7^{2-}(aq) + H_2O(l) \rightleftharpoons C_6H_5O_7^{3-}(aq) + H_3O^+(aq) \qquad K_a = 4.0 \times 10^{-7}$$

31. The amphiprotic species in the equations above are

A. $H_3C_6H_5O_7(aq)$, $HC_6H_5O_7^{2-}(aq)$, and $H_2O(l)$

B. $H_2C_6H_5O_7^-(aq)$, $HC_6H_5O_7^{2-}(aq)$, and $H_2O(l)$

C. $H_3C_6H_5O_7(aq)$ and $H_2C_6H_5O_7^-(aq)$

D. $HC_6H_5O_7^{2-}(aq)$ and $C_6H_5O_7^{3-}(aq)$

32. Which of the following statements about K_a and K_b values applies to the equations above?

A. The K_a of $H_3C_6H_5O_7(aq)$ is less than the K_b of $HC_6H_5O_7^{2-}(aq)$.

B. The K_b of $HC_6H_5O_7^{2-}(aq)$ is greater than the K_b of $C_6H_5O_7^{3-}(aq)$.

C. The K_a of $H_2C_6H_5O_7^-(aq)$ is greater than the K_b of $C_6H_5O_7^{3-}(aq)$.

D. The K_b of $H_2C_6H_5O_7^-(aq)$ is greater than the K_b of $HC_6H_5O_7^{2-}(aq)$.

Use the following information to answer the next two questions.

Lactic acid, $HC_3H_5O_3(aq)$, 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.

$$HC_3H_5O_3(aq) + H_2O(l) \rightleftharpoons C_3H_5O_3^-(aq) + H_3O^+(aq)$$

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.	$HC_3H_5O_3(aq)$ and $C_3H_5O_3^-(aq)$	$H_2O(l)$ and $H_3O^+(aq)$
B.	$HC_3H_5O_3(aq)$ and $C_3H_5O_3^-(aq)$	$C_3H_5O_3^-(aq)$ and $H_3O^+(aq)$
C.	$HC_3H_5O_3(aq)$ and $H_3O^+(aq)$	$H_2O(l)$ and $H_3O^+(aq)$
D.	$HC_3H_5O_3(aq)$ and $H_3O^+(aq)$	$C_3H_5O_3^-(aq)$ and $H_3O^+(aq)$

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 $\boldsymbol{a.b} \times 10^{-\boldsymbol{cd}}$ mol/L. The values of $\boldsymbol{a}$, $\boldsymbol{b}$, $\boldsymbol{c}$, and $\boldsymbol{d}$ 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.

	$N_2O_4(g)$	$NO_2(g)$
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. $N_2O_4(g) \rightleftharpoons NO_2(g)$ $K_c = 0.295$

B. $N_2O_4(g) \rightleftharpoons 2\,NO_2(g)$ $K_c = 0.053\ 1$

C. $NO_2(g) \rightleftharpoons N_2O_4(g)$ $K_c = 3.39$

D. $2\,NO_2(g) \rightleftharpoons N_2O_4(g)$ $K_c = 18.8$

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 $H_2(g)$, 2.13 mmol of $I_2(g)$, and 3.74 mmol of HI(g).

$$H_2(g) + I_2(g) \rightleftharpoons 2\,HI(g)$$

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

Equation I $CO_2(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$

Equation II $H_2CO_3(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$

36. *If the concentration of $CO_2(aq)$ in the blood increases, then the equilibria will shift to the* ___***i***___ *, and the concentration of $HCO_3^-(aq)$ in the blood will* ___***ii***___ *.*

The statement above is completed by the information in row

Row	*i*	*ii*
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. $K_c = \dfrac{[H_2CO_3(aq)][H_2O(l)]}{[HCO_3^-(aq)][H_3O^+(aq)]}$

B. $K_c = \dfrac{[H_2CO_3(aq)]}{[HCO_3^-(aq)][H_3O^+(aq)]}$

C. $K_c = \dfrac{[HCO_3^-(aq)][H_3O^+(aq)]}{[H_2CO_3(aq)][H_2O(l)]}$

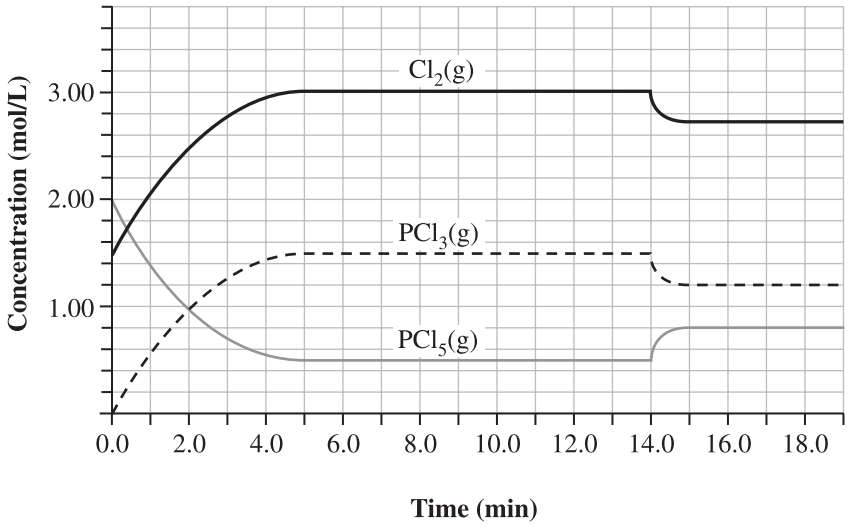
D. $K_c = \dfrac{[HCO_3^-(aq)][H_3O^+(aq)]}{[H_2CO_3(aq)]}$

Use the following information to answer the next question.

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

$$PCl_5(g) + \text{energy} \rightleftharpoons PCl_3(g) + Cl_2(g)$$

Equilibrium System



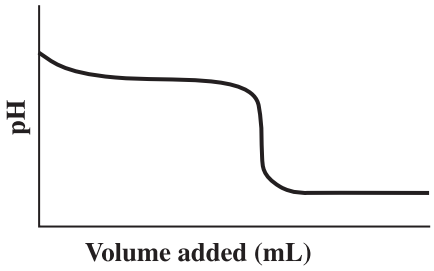
38. *In the equilibrium system represented in the diagram above, equilibrium was initially established at* ___***i***___ , *and the stress applied to the system at 14.0 minutes was* ___***ii***___ *in temperature.*

The statement above is completed by the information in row

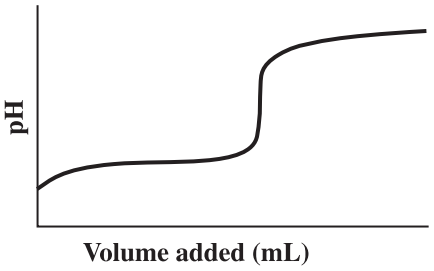
Row	*i*	*ii*
A.	4.5 min	an increase
B.	4.5 min	a decrease
C.	14.0 min	an increase
D.	14.0 min	a decrease

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

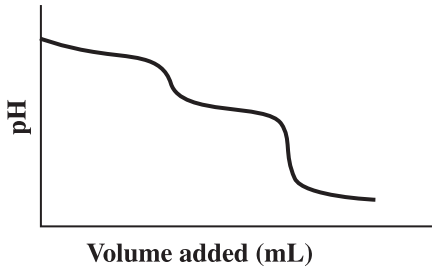
A.



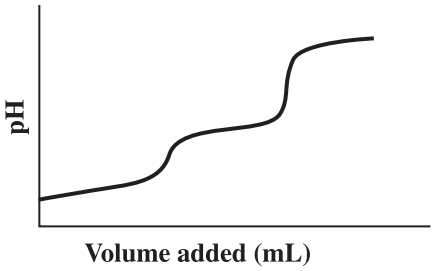
B.



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	$H_2(g) + Br_2(g) \rightleftharpoons 2\,HBr(g)$	5.0×10^{-18}
2	$H_2(g) + Cl_2(g) \rightleftharpoons 2\,HCl(g)$	2.5×10^{33}
3	$N_2(g) + O_2(g) \rightleftharpoons 2\,NO(g)$	2.0×10^{-31}
4	$H_2(g) + I_2(g) \rightleftharpoons 2\,HI(g)$	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 HF(aq)
2 $H_2S(aq)$
3 HOCl(aq)
4 $H_2SO_3(aq)$

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	$HClO_4$(aq) and $KClO_4$(aq)
III	H_2SO_4(aq) and $LiHSO_4$(aq)
IV	H_3PO_4(aq) and NaH_2PO_4(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.

$$2\,H_2S(g) + 3\,O_2(g) \rightarrow 2\,SO_2(g) + 2\,H_2O(g)$$

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.

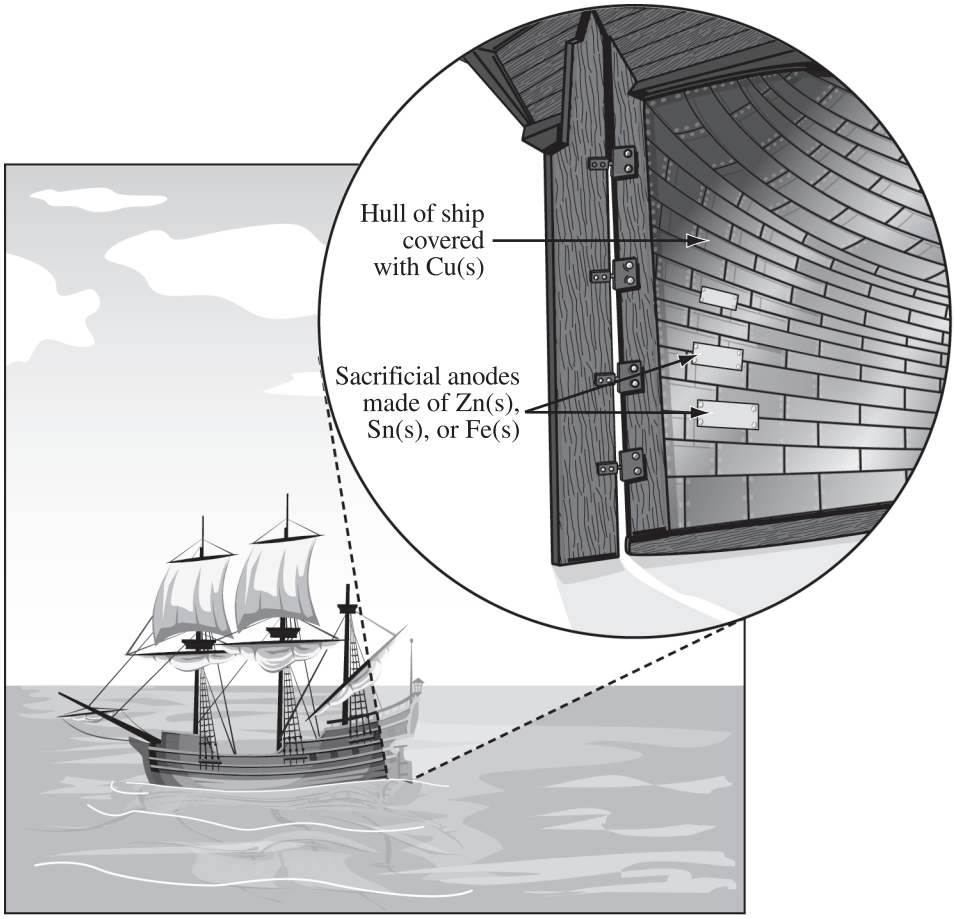
Written Response—10%

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

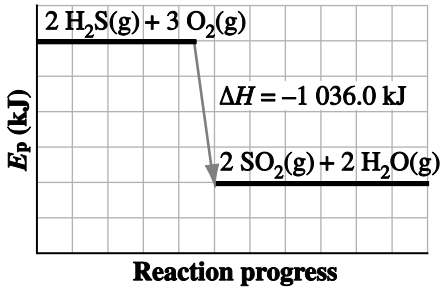
Key: MC–Multiple Choice; NR–Numerical Response

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	$2\,H_2S(g) + 3\,O_2(g) \rightarrow 2\,SO_2(g) + 2\,H_2O(g)$ $\Delta H° = \sum n\Delta_f H°_{(products)} - \sum n\Delta_f H°_{(reactants)}$ $= [(2\text{ mol})(-296.8\text{ kJ/mol}) + (2\text{ mol})(-241.8\text{ kJ/mol})] - [(2\text{ mol})(-20.6\text{ kJ/mol}) + (3\text{ mol})(0\text{ kJ/mol})]$ $= (-1\,077.2\text{ kJ}) - (-41.2\text{ kJ})$ $= -1\,036.0\text{ kJ}$	• 1 mark for correct method • 1 mark for substitution consistent with method • 1 mark for correct answer
1.b.	2	**Combustion of $H_2S(g)$**  **Note:** Can also be labelled reactants and products.	• 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	$3\,H_2(g) + N_2(g) \rightleftharpoons 2\,NH_3(g) + 91.8\ kJ$	• 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.	• 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.		**Corrosion Explanation** The corrosion of copper is the spontaneous oxidation reaction that occurs when copper reacts with water and oxygen. Solid copper is oxidized to $Cu^{2+}(aq)$. $O_2(g) + 2\,H_2O(l) + 4\,e^- \rightarrow 4\,OH^-(aq)$ $\quad E°_{reduction} = +0.40$ V $Cu(s) \rightarrow Cu^{2+}(aq) + 2\,e^-$ $\quad E°_{reduction} = +0.34$ V $O_2(g) + 2\,H_2O(l) + 2\,Cu(s) \rightarrow 4\,OH^-(aq) + 2\,Cu^{2+}(aq)$ $\quad \Delta E°_{cell} = +0.06$ V OR $\rightarrow 2\,Cu(OH)_2(s)$ **Sacrificial Anode Explanation** 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. If both iron and copper are present with water and oxygen, the reaction that occurs is the following. $O_2(g) + 2\,H_2O(l) + 2\,Fe(s) \rightarrow 4\,OH^-(aq) + 2\,Fe^{2+}(aq)$ $\quad \Delta E° = +0.85$ V OR $\rightarrow 2\,Fe(OH)_2(s)$	*Key Component* • explanation that Fe(s), Sn(s) or Zn(s) reacts spontaneously with the oxidizing agent before Cu(s) *Support* • explanation of the corrosion of copper • explanation of the sacrificial anode • relevant equations and $E°_{cell}$ calculation