Chemistry 30 Released Items

2011 Released Diploma Examination Items
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**Introduction**

The questions presented in this booklet are from the June 2009 Chemistry 30 Diploma Examination. This material, along with the program of studies, *2011–2012 Subject Bulletin, Assessment Highlights*, and June 2009 Diploma Examination Results, can provide insights that assist you with decisions relative to instructional programming.

These examination items are released in both English and French by the Assessment Sector.

Of the 56 questions on the June 2009 Chemistry 30 Diploma Examination, four are not being released. One question (MC10) was deleted from the original examination as it was judged to be flawed. Three questions (MC38, NR1, and NR8) are similar to items that are part of the equating process for Chemistry 30.
Chemistry 30 Diploma Examination June 2009
Part B: Multiple-Choice and Numerical-Response Questions

Numerical Response

1. THIS QUESTION IS NOT BEING RELEASED.
Use the following information to answer the next two questions.

Some matches consist of a wooden stick and a head that contains tetraphosphorous trisulfide, \( \text{P}_4\text{S}_3(s) \), and that can be ignited on any rough surface. When the match is drawn across a rough surface, enough heat is generated to start the reaction represented by the following equation.

\[
\text{P}_4\text{S}_3(s) + 8 \text{O}_2(g) \rightarrow \text{P}_4\text{O}_{10}(s) + 3 \text{SO}_2(g) \\
\Delta_f H_{\text{P}_4\text{S}_3(s)} = -155.0 \text{ kJ/mol} \\
\Delta_f H_{\text{P}_4\text{O}_{10}(s)} = -2 984.0 \text{ kJ/mol}
\]

1. The energy released during the combustion of the wood in the match originally came from the
   A. sun
   B. atmosphere
   C. formation of cellulose in the wood
   D. decomposition of carbon dioxide and water

2. Which of the following potential energy diagrams represents the reaction that occurs at the head of the match?

A. ![Diagram A]

B. ![Diagram B]

C. ![Diagram C]

D. ![Diagram D]
Use the following information to answer the next two questions.

Glucose is produced by plants during photosynthesis as represented by the following overall equation.

\[ 6 \text{CO}_2(g) + 6 \text{H}_2\text{O}(l) \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(s) + 6 \text{O}_2(g) \]

3. The balanced equation and the enthalpy change for photosynthesis can be represented by

   A. \[ 6 \text{CO}_2(g) + 6 \text{H}_2\text{O}(l) \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(s) + 6 \text{O}_2(g) + 2538.5 \text{kJ} \]
   B. \[ 6 \text{CO}_2(g) + 6 \text{H}_2\text{O}(l) + 2538.5 \text{kJ} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(s) + 6 \text{O}_2(g) \]
   C. \[ 6 \text{CO}_2(g) + 6 \text{H}_2\text{O}(l) \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(s) + 6 \text{O}_2(g) + 2802.5 \text{kJ} \]
   D. \[ 6 \text{CO}_2(g) + 6 \text{H}_2\text{O}(l) + 2802.5 \text{kJ} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(s) + 6 \text{O}_2(g) \]

4. If glucose produced during photosynthesis is completely burned in an open flame, the enthalpy change is

   A. greater than it is during cellular respiration because the production of \( \text{H}_2\text{O}(g) \) releases more energy than does the production of \( \text{H}_2\text{O}(l) \)
   B. less than it is during cellular respiration because the production of \( \text{H}_2\text{O}(g) \) releases less energy than does the production of \( \text{H}_2\text{O}(l) \)
   C. the same as it is in cellular respiration because they are identical processes
   D. the same as it is in the plant because the enthalpy change is independent of the state of the products
Use the following information to answer the next two questions.

Sour gas is a mixture of predominantly methane gas and hydrogen sulfide gas. The Claus process can be used to remove hydrogen sulfide gas from sour gas as represented by the following equation.

$$8 \text{H}_2\text{S(g)} + 4 \text{O}_2\text{(g)} \rightarrow \text{S}_8\text{(s)} + 8 \text{H}_2\text{O(g)} \quad \Delta H^\circ = -1769.6 \text{ kJ}$$

**Numerical Response**

2. The enthalpy change for 1.00 mol of H$_2$S(g) during the Claus process, expressed in scientific notation, is $\pm a.bc \times 10^d \text{ kJ/mol}$. 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.)

5. During the Claus process, energy is _____i_____ the surroundings, and energy is included as a _____ii_____ in the balanced equation.

The statement above is completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th>i</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>absorbed from</td>
<td>reactant</td>
</tr>
<tr>
<td>B.</td>
<td>absorbed from</td>
<td>product</td>
</tr>
<tr>
<td>C.</td>
<td>released to</td>
<td>reactant</td>
</tr>
<tr>
<td>D.</td>
<td>released to</td>
<td>product</td>
</tr>
</tbody>
</table>
A student experimentally determined the molar enthalpy of formation for carbon dioxide gas by burning 1.04 g of C(s) in a calorimeter. The student found that burning the carbon released enough heat to increase the temperature of 1.00 kg of water from 12.00 °C to 19.36 °C.

6. In this experiment, the student determined that the molar enthalpy of formation for carbon dioxide was
   A. $-1.30 \times 10^{3}$ kJ/mol
   B. $-3.56 \times 10^{2}$ kJ/mol
   C. $-30.8$ kJ/mol
   D. $-2.67$ kJ/mol

7. As dry air is heated from 15.0 °C to 25.0 °C by the combustion of methane in a furnace, the air would primarily undergo
   A. a decrease in kinetic energy
   B. an increase in kinetic energy
   C. a decrease in potential energy
   D. an increase in potential energy
8. According to the equations above, the enthalpy change for 2 C₂H₅OH(l) + O₂(g) → 2 C₂H₄O(l) + 2 H₂O(l) is
   A. +834.0 kJ  
   B. +752.8 kJ  
   C. –400.8 kJ  
   D. –532.8 kJ

9. The formation of titanium(IV) oxide is _____i____, and the reactants have _____ii_____ potential energy than the products.

   The statement above is completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th>i</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>endothermic</td>
<td>higher</td>
</tr>
<tr>
<td>B.</td>
<td>endothermic</td>
<td>lower</td>
</tr>
<tr>
<td>C.</td>
<td>exothermic</td>
<td>higher</td>
</tr>
<tr>
<td>D.</td>
<td>exothermic</td>
<td>lower</td>
</tr>
</tbody>
</table>
Use the following information to answer the next two questions.

Xenon tetrafluoride is a binary compound made from a noble gas. The formation of xenon tetrafluoride can be represented by the following equation.

\[
\text{Xe(g)} + 2 \text{F}_2(\text{g}) \rightarrow \text{XeF}_4(\text{s}) \quad \Delta_f H^\circ = -251 \text{ kJ}
\]

**Numerical Response**

3. The energy that is transferred when 69.1 g of XeF₄(s) is produced is _________ kJ.

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

**Numerical Response**

4. The oxidation number of xenon in

- XeF₂ is +/- __________ (Record in the first column)
- XeF₃ is +/- __________ (Record in the second column)
- XeF₆ is +/- __________ (Record in the third column)
- XeO₃ is +/- __________ (Record in the fourth column)

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

10.

**THIS QUESTION WAS DELETED FROM THE ORIGINAL EXAMINATION.**
Use the following information to answer the next two questions.

When copper is first obtained from ores, it is processed into impure slabs called blister copper. Pure copper is refined from the blister copper slabs in an electrochemical cell. The blister copper slabs are used as the anode and sheets of pure copper are used as the cathode, as shown in the following diagram.

The electrochemical cell used in the refining of copper is _____i____, and the reaction is _____ii____.

The statement above is completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th>i</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>voltaic</td>
<td>spontaneous</td>
</tr>
<tr>
<td>B.</td>
<td>voltaic</td>
<td>nonspontaneous</td>
</tr>
<tr>
<td>C.</td>
<td>electrolytic</td>
<td>spontaneous</td>
</tr>
<tr>
<td>D.</td>
<td>electrolytic</td>
<td>nonspontaneous</td>
</tr>
</tbody>
</table>
Numerical Response

5. Match four of the numbers in the diagram of the electrochemical cell used in the refining of copper with their descriptions given below.

Site where reduction occurs __________ (Record in the first column)
Direction of anion movement __________ (Record in the second column)
Direction of electron movement __________ (Record in the third column)
Electrode that increases in mass __________ (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.

3 I\textsubscript{2}(s) + 5 ClO\textsubscript{3}\textsuperscript{−}(aq) + 3 H\textsubscript{2}O(l) → 6 HIO\textsubscript{3}(aq) + 5 Cl\textsuperscript{−}(aq)

12. In an acidic medium, the balanced reduction half-reaction for the reaction represented by the equation above is

A. I\textsubscript{2}(s) + 2 H\textsuperscript{+}(aq) + 4 e\textsuperscript{−} → 2 I\textsuperscript{−}(aq) + H\textsubscript{2}O(l)
B. 2 H\textsubscript{2}O(l) + 2 e\textsuperscript{−} → H\textsubscript{2}(g) + 2 OH\textsuperscript{−}(aq)
C. ClO\textsubscript{3}\textsuperscript{−}(aq) + 6 H\textsuperscript{+}(aq) + 6 e\textsuperscript{−} → Cl\textsuperscript{−}(aq) + 3 H\textsubscript{2}O(l)
D. ClO\textsubscript{3}\textsuperscript{−}(aq) + 3 H\textsubscript{2}O(l) + 6 e\textsuperscript{−} → Cl\textsuperscript{−}(aq) + 6 OH\textsuperscript{−}(aq)

13. In order to prevent corrosion, a sacrificial anode is connected to an underground propane tank that is made of iron metal. Which of the following metals could not function as the sacrificial anode?

A. Copper
B. Chromium
C. Aluminium
D. Magnesium
Use the following information to answer the next question.

14. Which of the following equations represents the net reaction that occurs in the electrochemical cell?

A. \[2 \text{Ag(s) + Sn}^{2+} (aq) \rightarrow 2 \text{Ag}^+ (aq) + \text{Sn(s)}\]

B. \[2 \text{Ag(s) + Sn(s) \rightarrow 2 Ag}^+ (aq) + \text{Sn}^{2+} (aq)\]

C. \[2 \text{Ag}^+ (aq) + \text{Sn}^{2+} (aq) \rightarrow 2 \text{Ag(s) + Sn(s)}\]

D. \[2 \text{Ag}^+ (aq) + \text{Sn(s) \rightarrow 2 Ag(s) + Sn}^{2+} (aq)\]
Use the following information to answer the next question.

A student is given three metal strips and is asked to identify each strip as silver, lead, or zinc. The student labels the strips X(s), Y(s), and Z(s) and tests each strip in a Cu(NO$_3$)$_2$(aq) solution and a Ni(NO$_3$)$_2$(aq) solution. The student’s observations are shown below.

<table>
<thead>
<tr>
<th></th>
<th>Cu(NO$_3$)$_2$(aq)</th>
<th>Ni(NO$_3$)$_2$(aq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X(s)</td>
<td>black precipitate</td>
<td>no reaction</td>
</tr>
<tr>
<td>Y(s)</td>
<td>black precipitate</td>
<td>black precipitate</td>
</tr>
<tr>
<td>Z(s)</td>
<td>no reaction</td>
<td>no reaction</td>
</tr>
</tbody>
</table>

15. Which of the following rows identifies the metals that the student was given?

<table>
<thead>
<tr>
<th>Row</th>
<th>X(s)</th>
<th>Y(s)</th>
<th>Z(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>silver</td>
<td>lead</td>
<td>zinc</td>
</tr>
<tr>
<td>B.</td>
<td>silver</td>
<td>zinc</td>
<td>lead</td>
</tr>
<tr>
<td>C.</td>
<td>lead</td>
<td>silver</td>
<td>zinc</td>
</tr>
<tr>
<td>D.</td>
<td>lead</td>
<td>zinc</td>
<td>silver</td>
</tr>
</tbody>
</table>
16. Which of the equations numbered above represents a reaction in which the metal is oxidized?

A. I and II only
B. I, II, and V
C. I, IV, and V
D. III and IV
17. If the $\text{Ni}^{2+}(\text{aq}) + 2\, \text{e}^- \rightarrow \text{Ni}($s$)$ half-reaction is designated as the reference half-reaction with an electrode potential of 0.00 V, then the electrical potential for the $\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Fe}^{2+}(\text{aq})$ half-reaction is

A. +1.03 V
B. +0.51 V
C. –0.51 V
D. –1.03 V

Use the following information to answer the next question.

$\text{Ce}^{4+}(\text{aq}) + \text{Cu}^+(\text{aq}) \rightarrow \text{Ce}^{3+}(\text{aq}) + \text{Cu}^{2+}(\text{aq})$ spontaneous
$\text{Co}^{2+}(\text{aq}) + \text{Ce}^{4+}(\text{aq}) \rightarrow \text{Co}^{3+}(\text{aq}) + \text{Ce}^{3+}(\text{aq})$ nons spontaneous
$2\, \text{Cu}^{2+}(\text{aq}) + \text{Mn}($s$) \rightarrow 2\, \text{Cu}^+(\text{aq}) + \text{Mn}^{2+}(\text{aq})$ spontaneous

18. The oxidizing agents above, listed from strongest to weakest, are

<table>
<thead>
<tr>
<th>Row</th>
<th>Strongest</th>
<th>Weakest</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>$\text{Cu}^{2+}(\text{aq})$</td>
<td>$\text{Mn}^{2+}(\text{aq})$</td>
</tr>
<tr>
<td>B.</td>
<td>$\text{Ce}^{4+}(\text{aq})$</td>
<td>$\text{Co}^{3+}(\text{aq})$</td>
</tr>
<tr>
<td>C.</td>
<td>$\text{Co}^{3+}(\text{aq})$</td>
<td>$\text{Ce}^{4+}(\text{aq})$</td>
</tr>
<tr>
<td>D.</td>
<td>$\text{Mn}($s$)$</td>
<td>$\text{Cu}^+(\text{aq})$</td>
</tr>
</tbody>
</table>
Use the following information to answer the next two questions.

Electrochemical Cell

19. The $E^\circ_{\text{cell}}$ for the electrochemical cell above is
   
   A. +1.10 V  
   B. +0.42 V  
   C. −0.42 V  
   D. −1.10 V

20. Which of the following statements applies to the operation of the electrochemical cell?
   
   A. A precipitate forms on the Zn(s) electrode.  
   B. The concentration of Zn$^{2+}$(aq) ions decreases.  
   C. Electrons move through the connecting wires toward the Zn(s) electrode.  
   D. The NO$_3^-$ (aq) ions move through the salt bridge toward the Zn(s) electrode.
Use the following information to answer the next two questions.

The oxygen content of waste water can be determined indirectly by measuring the concentration of iodine in a sample by titration with thiosulfate ions, $S_2O_3^{2-}(aq)$, as represented by the following equation.

$$I_2(aq) + 2 S_2O_3^{2-}(aq) \rightarrow 2 I^-(aq) + S_4O_6^{2-}(aq)$$

During waste-water treatment, a standardized 0.125 mol/L sodium thiosulfate solution was used to titrate 10.0 mL samples of aqueous iodine.

<table>
<thead>
<tr>
<th>Volume of $S_2O_3^{2-}(aq)$ Used During the Titration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>Final burette reading (mL)</td>
</tr>
<tr>
<td>Initial burette reading (mL)</td>
</tr>
</tbody>
</table>

21. In the titration reaction, the reducing agent is ____i____ and ____ii____ atoms are reduced.

The statement above is completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th>i</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>$I_2(aq)$</td>
<td>iodine</td>
</tr>
<tr>
<td>B.</td>
<td>$I_2(aq)$</td>
<td>sulfur</td>
</tr>
<tr>
<td>C.</td>
<td>$S_2O_3^{2-}(aq)$</td>
<td>iodine</td>
</tr>
<tr>
<td>D.</td>
<td>$S_2O_3^{2-}(aq)$</td>
<td>sulfur</td>
</tr>
</tbody>
</table>

**Numerical Response**

6. The concentration of $I_2(aq)$, expressed in scientific notation, is $a.bc \times 10^{-d}$ 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.)
In an experiment to study the spontaneity of redox reactions, a student placed a different strip of metal into five separate test tubes, each containing 1.0 mol/L copper(II) nitrate solution, as shown below.

22. The test tubes in which a spontaneous redox reaction will occur during this experiment are labelled

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

Use the following information to answer the next question.

Bleach works by reacting with coloured chemicals that cause stains. Common household bleach contains aqueous sodium hypochlorite, NaOCl(aq), and its production is represented by the following equilibrium equation.

\[
\text{Cl}_2(g) + 2 \text{OH}^-(aq) \rightleftharpoons \text{OCl}^-\text{(aq)} + \text{Cl}^-\text{(aq)} + \text{H}_2\text{O(l)}
\]

23. In the equation above, the species that undergoes disproportionation is

A. Cl\textsubscript{2}(g)
B. OH\textsuperscript{−}(aq)
C. OCl\textsuperscript{−}(aq)
D. H\textsubscript{2}O(l)
Use the following information to answer the next question.

3 I_2(s) + 5 ClO_3^-(aq) + 3 H_2O(l) → 6 HIO_3(aq) + 5 Cl^-(aq)

24. In the reaction represented by the equation above, the species that loses electrons is ____ i ____, and the total number of electrons transferred in the reaction is ____ ii ____.

The statement above is completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th>i</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>I_2(s)</td>
<td>30</td>
</tr>
<tr>
<td>B.</td>
<td>I_2(s)</td>
<td>10</td>
</tr>
<tr>
<td>C.</td>
<td>ClO_3^-(aq)</td>
<td>30</td>
</tr>
<tr>
<td>D.</td>
<td>ClO_3^-(aq)</td>
<td>10</td>
</tr>
</tbody>
</table>

Use the following information to answer the next question.

<table>
<thead>
<tr>
<th>Carbon-Containing Compounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 C_2H_4(g)</td>
</tr>
<tr>
<td>2 CaC_2(s)</td>
</tr>
<tr>
<td>3 CH_3Cl(g)</td>
</tr>
<tr>
<td>4 CH_3OH(l)</td>
</tr>
</tbody>
</table>

Numerical Response

7. 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.)
Cycloheptane and cycloheptene are both colourless liquids. One method used to differentiate between cycloheptane and cycloheptene is to add a few drops of orange-coloured aqueous bromine to samples of each organic compound.

25. When aqueous bromine is added to cycloheptane and cycloheptene, the cycloheptane undergoes __i__ reaction, and the cycloheptene undergoes __ii__ reaction.

The statement above is completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th>i</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>an addition</td>
<td>a substitution</td>
</tr>
<tr>
<td>B.</td>
<td>an addition</td>
<td>an addition</td>
</tr>
<tr>
<td>C.</td>
<td>a substitution</td>
<td>a substitution</td>
</tr>
<tr>
<td>D.</td>
<td>a substitution</td>
<td>an addition</td>
</tr>
</tbody>
</table>

26. Cycloheptane is __i__ hydrocarbon, and cycloheptene is __ii__ hydrocarbon.

The statement above is completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th>i</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>a saturated</td>
<td>a saturated</td>
</tr>
<tr>
<td>B.</td>
<td>a saturated</td>
<td>an unsaturated</td>
</tr>
<tr>
<td>C.</td>
<td>an unsaturated</td>
<td>a saturated</td>
</tr>
<tr>
<td>D.</td>
<td>an unsaturated</td>
<td>an unsaturated</td>
</tr>
</tbody>
</table>
Numerical Response

8.

THIS QUESTION IS NOT BEING RELEASED.
Use the following information to answer the next question.

<table>
<thead>
<tr>
<th>Reaction Equation</th>
</tr>
</thead>
</table>
| I \[ H-C\(\text{C}-\text{O}\)\]
| \[\text{H}\]
| \[\text{H}\]
| \[\text{O}-\text{H}\]
| \[\text{II}\]
| \[H-C\(\text{C}-\text{O}\)\]
| \[\text{H}\]
| \[\text{H}\]
| \[\text{H}\]
| \[\text{O}-\text{H}\]

Names and Terms

1. Ethanol
2. Ethanoic acid
3. Ethyl ethanoate
4. Methyl ethanoate
5. Ester
6. Alcohol
7. Polymer
8. Esterification
9. Polymerization

Numerical Response

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

Type of reaction ________ (Record in the first column)
Name of compound I ________ (Record in the second column)
Name of compound II ________ (Record in the third column)
Classification of compound 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 structural diagrams represent organic compounds with common industrial uses.

![Chemical structures](image)

**Numerical Response**

10. Match the structural diagrams above with their classifications given below.

   Alcohol __________ (Record in the first column)
   Aromatic __________ (Record in the second column)
   Carboxylic acid __________ (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 question.

**Organic Compounds**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3-methylcyclohexene</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>1,2-dibromopentane</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>2,2-dimethylbutane</td>
<td>6</td>
</tr>
</tbody>
</table>

**Numerical Response**

11. 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.

A student drew the structural diagram shown below.

```
CH₃
CH₃CH₂CH₃
```

27. 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

<table>
<thead>
<tr>
<th>Row</th>
<th>i</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>methyl</td>
<td>propylbutane</td>
</tr>
<tr>
<td>B.</td>
<td>methyl</td>
<td>propylcyclobutane</td>
</tr>
<tr>
<td>C.</td>
<td>propyl</td>
<td>methylbutane</td>
</tr>
<tr>
<td>D.</td>
<td>propyl</td>
<td>methylcyclobutane</td>
</tr>
</tbody>
</table>
Use the following information to answer the next question.

28. An ester functional group is found in
   
   A. II and III only
   B. II, III, and IV
   C. III only
   D. IV only
29. Which of the following solutions has the **lowest** pH?

   A. 1.5 mol/L H₃PO₄(aq)
   B. 0.50 mol/L HNO₃(aq)
   C. 0.75 mol/L H₂CO₃(aq)
   D. 1.0 mol/L HCOOH(aq)

---

30. For the position of the equilibrium to shift toward the products, the pressure of the system should be **i** by adjusting the volume of the closed system and the temperature should be **ii**.

   The statement above is completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th>i</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>increased</td>
<td>increased</td>
</tr>
<tr>
<td>B.</td>
<td>increased</td>
<td>decreased</td>
</tr>
<tr>
<td>C.</td>
<td>decreased</td>
<td>increased</td>
</tr>
<tr>
<td>D.</td>
<td>decreased</td>
<td>decreased</td>
</tr>
</tbody>
</table>

---

31. When a catalyst is added to this system at equilibrium, the position of the equilibrium **i** and the value of ΔH° **ii**.

   The statement above is completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th>i</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>shifts right</td>
<td>increases</td>
</tr>
<tr>
<td>B.</td>
<td>shifts right</td>
<td>does not change</td>
</tr>
<tr>
<td>C.</td>
<td>does not change</td>
<td>increases</td>
</tr>
<tr>
<td>D.</td>
<td>does not change</td>
<td>does not change</td>
</tr>
</tbody>
</table>
Use the following information to answer the next three questions.

An equilibrium system was established in a 1.00 L flask at 25 °C as represented by the following equation.

\[
\text{H}_2(\text{g}) + \text{I}_2(\text{g}) + 53.0 \text{ kJ} \rightleftharpoons 2 \text{HI(g)}
\]

colourless  purple  colourless

At equilibrium, the flask contained 0.057 mmol of H₂(g), 1.07 mmol of I₂(g), and 1.87 mmol of HI(g).

32. Which of the following changes, when applied to this equilibrium system, would change the value of the equilibrium constant?
   A. An addition of a catalyst
   B. An increase in temperature
   C. An addition of hydrogen gas
   D. A decrease in the volume of the flask

33. The value of the equilibrium constant for this system at 25 °C is
   A. 57
   B. 31
   C. 0.033
   D. 0.017

34. The empirical evidence that could be used to determine when this system reaches equilibrium is
   A. colour
   B. density
   C. total mass
   D. total pressure
35. Which of the following acids, when titrated with a 0.10 mol/L NaOH(aq) solution, could produce the titration curve shown above?

A. HF(aq)  
B. HCl(aq)  
C. H₂SO₄(aq)  
D. H₂CO₃(aq)
Use the following information to answer the next question.

\[
\text{H}_2\text{SO}_3(aq) + \text{F}^-(aq) \rightleftharpoons \text{HSO}_3^-(aq) + \text{HF}(aq)
\]

36. In the reaction represented by the equation above, the amphiprotic species is

A. \( \text{H}_2\text{SO}_3(aq) \)
B. \( \text{HSO}_3^-(aq) \)
C. \( \text{HF}(aq) \)
D. \( \text{F}^-(aq) \)

Use the following information to answer the next question.

When xenon hexafluoride and water react, hydrofluoric acid is produced, as represented by the following equation.

\[
\text{XeF}_6(s) + 3 \text{H}_2\text{O}(l) \rightarrow \text{XeO}_3(aq) + 6 \text{HF}(aq)
\]

37. During the reaction, the pH of the solution will _____ and the pOH of the solution will _____.

The statement above is completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th>i</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>increase</td>
<td>increase</td>
</tr>
<tr>
<td>B.</td>
<td>increase</td>
<td>decrease</td>
</tr>
<tr>
<td>C.</td>
<td>decrease</td>
<td>increase</td>
</tr>
<tr>
<td>D.</td>
<td>decrease</td>
<td>decrease</td>
</tr>
</tbody>
</table>
Use the following information to answer the next two questions.

An equilibrium system is established in a 1.00 L flask at 800 °C, as represented by the following equation.

\[
\text{PCl}_3(g) + \text{Cl}_2(g) \rightleftharpoons \text{PCl}_5(g) \quad \Delta H = 87.9 \text{ kJ} \quad K_c = 1.90
\]

39. Which of the following graphs represents the change in the equilibrium system at time \(x\) that results as the system is heated?

A. 

B. 

C. 

D. 

Numerical Response

12. At equilibrium, if the concentration of \(\text{PCl}_3(g)\) is 0.165 mol/L and the concentration of \(\text{PCl}_5(g)\) is 0.255 mol/L, then the equilibrium concentration of \(\text{Cl}_2(g)\), expressed in scientific notation, is \(a.bc \times 10^{-d}\) 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.)
40. Sulfurous acid is a _____ acid, and its conjugate base is _____.

The statement above is completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th>i</th>
<th>ii</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>monoprotic</td>
<td>amphiprotic</td>
</tr>
<tr>
<td>B.</td>
<td>monoprotic</td>
<td>polyprotic</td>
</tr>
<tr>
<td>C.</td>
<td>polyprotic</td>
<td>amphiprotic</td>
</tr>
<tr>
<td>D.</td>
<td>polyprotic</td>
<td>polyprotic</td>
</tr>
</tbody>
</table>

Use the following information to answer the next question.

Acidic precipitation can be formed when sulfur dioxide gas and water vapour in the air react, as represented by the following equation.

\[
\text{SO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_2\text{SO}_3(\text{aq})
\]

**Numerical Response**

13. The \(K_b\) of the conjugate base of sulfurous acid, expressed in scientific notation, is \(a.b \times 10^{-cd}\). 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.)

   __________________________

Use the following information to answer the next question.

A technician prepares 500 mL of a 0.3 mol/L \(\text{NH}_3(\text{aq})\) solution.

**Numerical Response**

14. The pH of the \(\text{NH}_3(\text{aq})\) solution is __________.

   (Record your three-digit answer in the numerical-response section on the answer sheet.)
Benzoic acid reacts with water as represented by the following equation.

\[ \text{C}_6\text{H}_5\text{COOH}(aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{C}_6\text{H}_5\text{COO}^-(aq) + \text{H}_3\text{O}^+(aq) \]

41. *The Brønsted–Lowry base that forms in the highest concentration in the benzoic acid solution is __i__, and this base will __ii__ a proton.*

The statement above is completed by the information in row

<table>
<thead>
<tr>
<th>Row</th>
<th><strong>i</strong></th>
<th><strong>ii</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>OH(^-)(aq)</td>
<td>accept</td>
</tr>
<tr>
<td>B.</td>
<td>OH(^-)(aq)</td>
<td>donate</td>
</tr>
<tr>
<td>C.</td>
<td>C(_6)H(_5)COO(^-)(aq)</td>
<td>accept</td>
</tr>
<tr>
<td>D.</td>
<td>C(_6)H(_5)COO(^-)(aq)</td>
<td>donate</td>
</tr>
</tbody>
</table>

Use the following information to answer the next question.

During an experiment, a student reacts aqueous phosphoric acid and excess aqueous sodium hydrogen carbonate.

42. The net ionic equation that represents the reaction that occurs at the second equivalence point in the experiment is

A. \[ \text{H}_3\text{PO}_4(aq) + 3 \text{NaHCO}_3(aq) \rightarrow \text{Na}_3\text{PO}_4(aq) + 3 \text{H}_2\text{CO}_3(aq) \]

B. \[ \text{H}_3\text{PO}_4(aq) + \text{HCO}_3^-(aq) \rightarrow \text{H}_2\text{PO}_4^-(aq) + \text{H}_2\text{CO}_3(aq) \]

C. \[ \text{H}_2\text{PO}_4^-(aq) + \text{HCO}_3^-(aq) \rightarrow \text{HPO}_4^{2-}(aq) + \text{H}_2\text{CO}_3(aq) \]

D. \[ \text{H}_2\text{PO}_4^-(aq) + 2 \text{HCO}_3^-(aq) \rightarrow \text{HPO}_4^{2-}(aq) + 2 \text{H}_2\text{CO}_3(aq) \]

You have now completed the examination.
If you have time, you may wish to check your answers.
# Chemistry 30 Diploma Examination June 2009
## Part B: Multiple-Choice and Numerical-Response Answers

Key: MC–Multiple Choice; NR–Numerical Response

<table>
<thead>
<tr>
<th>Question</th>
<th>Key</th>
<th>*Diff. %</th>
<th>Question</th>
<th>Key</th>
<th>*Diff. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>NR1</td>
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<td>n/a</td>
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<td>A</td>
<td>64.3</td>
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<td>1347 (any order)</td>
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<td>MC25</td>
<td>D</td>
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<td>B</td>
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<td>NR8</td>
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<td>B</td>
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<td>C</td>
<td>63.9</td>
<td>MC28</td>
<td>A</td>
<td>64.5</td>
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<td>NR3</td>
<td>83.6 or 83.7</td>
<td>64.2</td>
<td>MC29</td>
<td>B</td>
<td>58.7</td>
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<td>NR4</td>
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<td>MC32</td>
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<td>61.2</td>
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<td>NR14</td>
<td>11.4</td>
<td>18.9</td>
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<td>MC41</td>
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<td>A</td>
<td>71.4</td>
<td>MC42</td>
<td>C</td>
<td>60.5</td>
</tr>
</tbody>
</table>

*Difficulty–percentage of students answering the question correctly