



For further information, contact Debra Campbell [Debra.Campbell@gov.ab.ca](mailto:Debra.Campbell@gov.ab.ca) or  
Kathryn O'Grady-Morris [Kathryn.OGrady-Morris@gov.ab.ca](mailto:Kathryn.OGrady-Morris@gov.ab.ca) or  
John Rymer [John.Rymer@gov.ab.ca](mailto:John.Rymer@gov.ab.ca) at the Learner Assessment Branch  
at (780) 427-0010. To call toll-free from outside Edmonton, dial 310-0000.

Our Internet address is [www.education.gov.ab.ca](http://www.education.gov.ab.ca).

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\* For more information regarding the scoring of the written-response questions refer to the *Chemistry Archived Bulletin Information* located at [http://www.education.gov.ab.ca/K\\_12/testing/diploma/bulletins/math-science/Chem30/Chem30\\_Archive.pdf](http://www.education.gov.ab.ca/K_12/testing/diploma/bulletins/math-science/Chem30/Chem30_Archive.pdf)

## ***Introduction***

The questions presented in this booklet are from the June 2003 *Chemistry 30 Diploma Examination*. A simple table can be found on the extranet that provides specific information about this examination for your particular school. This material, along with the program of studies, subject bulletin, and the assessment highlights, can provide insights that assist you with decisions relative to instructional programming.

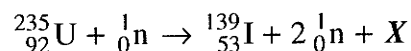
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## Chemistry 30 Released Questions, 2005

1. Coal is fossilized plant matter. The energy in coal originates from
- A. plants
  - B. the sun
  - C. the process of fossilization
  - D. radioactive decay at Earth's core

Use the following equation to answer the next question.



2. Substance  $X$  in the reaction above is

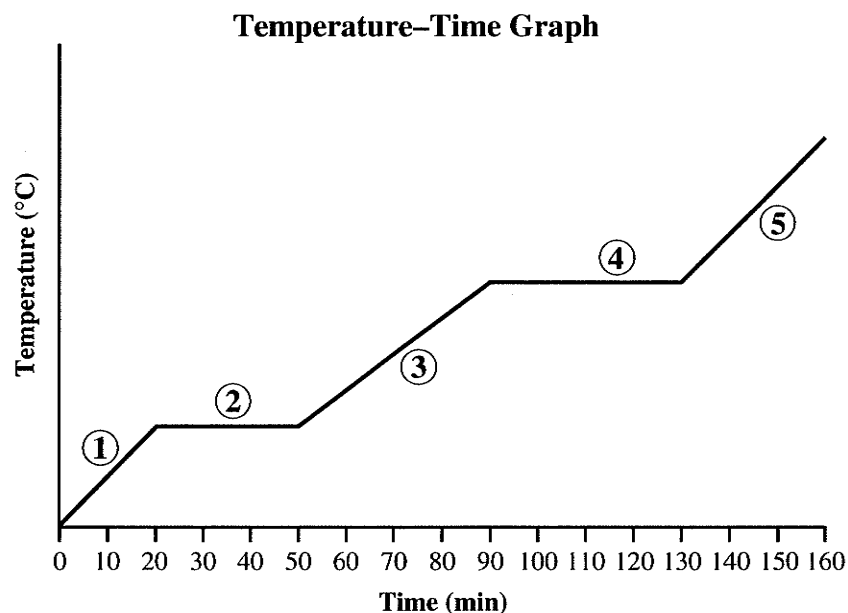
- A.  ${}_{42}^{94}\text{Mo}$
  - B.  ${}_{42}^{95}\text{Mo}$
  - C.  ${}_{39}^{89}\text{Y}$
  - D.  ${}_{39}^{95}\text{Y}$
- 

3. Of the equations below, which equation represents a change that would release the **least** amount of energy?

- A.  $\text{Fe}_{(l)} \rightarrow \text{Fe}_{(s)}$
- B.  ${}_1^2\text{H} + {}_0^1\text{n} \rightarrow {}_2^4\text{He} + {}_0^1\text{n}$
- C.  $2\text{K}_{(s)} + 2\text{H}_2\text{O}_{(l)} \rightarrow 2\text{KOH}_{(aq)} + \text{H}_{2(g)}$
- D.  $2\text{CH}_3\text{OH}_{(l)} + 3\text{O}_{2(g)} \rightarrow 2\text{CO}_{2(g)} + 4\text{H}_2\text{O}_{(g)}$

Use the following information to answer the next question.

Energy was added at a constant rate to a solid substance. The temperature of the substance was recorded over time, as shown in the graph below.



### Numerical Response

- 1.** Match four of the numbers on the graph above with the appropriate description given below.

The region where the change is mainly due to an increase in translational energy \_\_\_\_\_  
(Record in the **first** column)

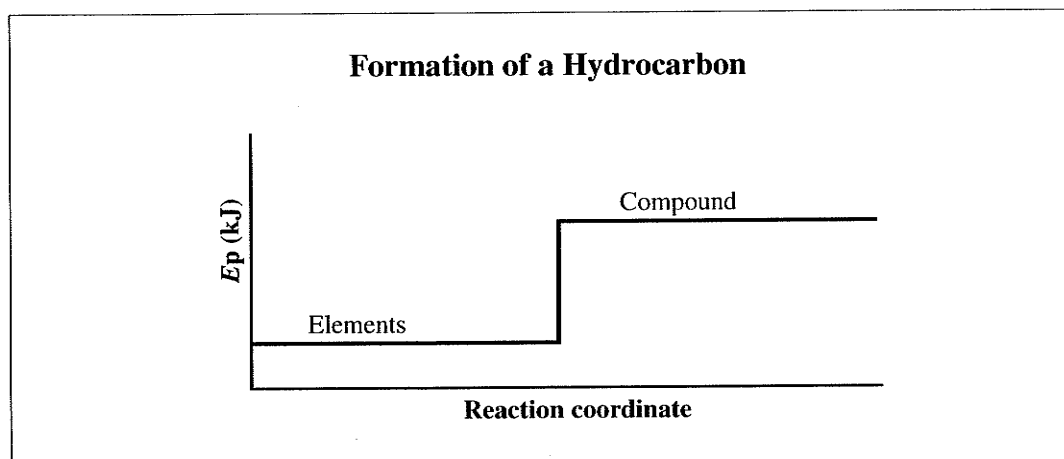
The region where melting occurs \_\_\_\_\_  
(Record in the **second** column)

The region where the largest change in potential energy occurs \_\_\_\_\_  
(Record in the **third** column)

The region where the smallest change in kinetic energy occurs \_\_\_\_\_  
(Record in the **fourth** column)

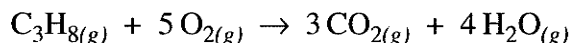
(Record your answer in the numerical-response section on the answer sheet.)

Use the following diagram to answer the next question.



4. The graph above could represent the formation of
- A. ethene
  - B. ethane
  - C. butane
  - D. pentane
- 
5. When citrus fruit growers are expecting a heavy frost, they spray their trees with water. The water freezes and helps protect the fruit from frost damage because as the water freezes, it
- A. absorbs heat, which warms the fruit
  - B. releases heat and cools the fruit without freezing it
  - C. releases heat, which prevents the fruit from freezing
  - D. absorbs heat that would otherwise cause the fruit to spoil

In 1999, the Breitling Orbiter 3 became the first balloon to circumnavigate the world. The air in the balloon was heated by the combustion of propane, which can be represented by the equation



The diagrams that were present on the examination have not been included due to copyright restrictions. What follows is a description of the two diagrams taken from the *Globe and Mail*.

There were two diagrams. The diagram on the left was titled “Breitling Orbiter 3 balloon” and the diagram on the right was titled “Breitling Orbiter capsule.”

The Breitling Orbiter 3 balloon diagram is a picture of the balloon with a capsule hanging from the balloon. The balloon has three sections labelled. At the top of the balloon is a helium balloon, below it is the helium chamber, and below the helium chamber is a hot air chamber. Between the helium chamber and the helium balloon are helium vents. The entire balloon is surrounded with an outer mylar skin.

The Breitling Orbiter capsule diagram is an enlarged picture of the capsule that hangs from the balloon. The capsule is cylindrical in shape and has 28 propane tanks attached to its sides. The capsule height is 2.25 m, which is much smaller in size compared to the Orbiter 3 balloon.

—based on *The Globe and Mail*

6. The molar heat of combustion of propane for the reaction shown in the equation above is
- A.  $-103.8 \text{ kJ/mol}$
  - B.  $-2\,043.9 \text{ kJ/mol}$
  - C.  $-2\,219.9 \text{ kJ/mol}$
  - D.  $-2\,251.5 \text{ kJ/mol}$



Use your recorded answer from **Multiple Choice 6** to answer **Numerical Response 2**.\*

**Numerical Response**

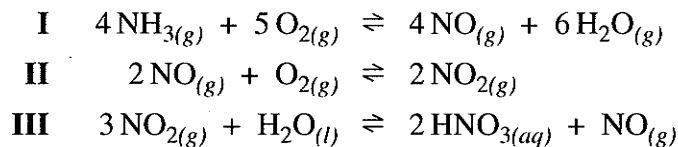
- 2.** The amount of energy required to heat the air in the balloon to flight temperature and initiate flight is  $1.00 \times 10^8$  kJ. The mass of propane required to heat this air is \_\_\_\_\_ Mg.

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

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

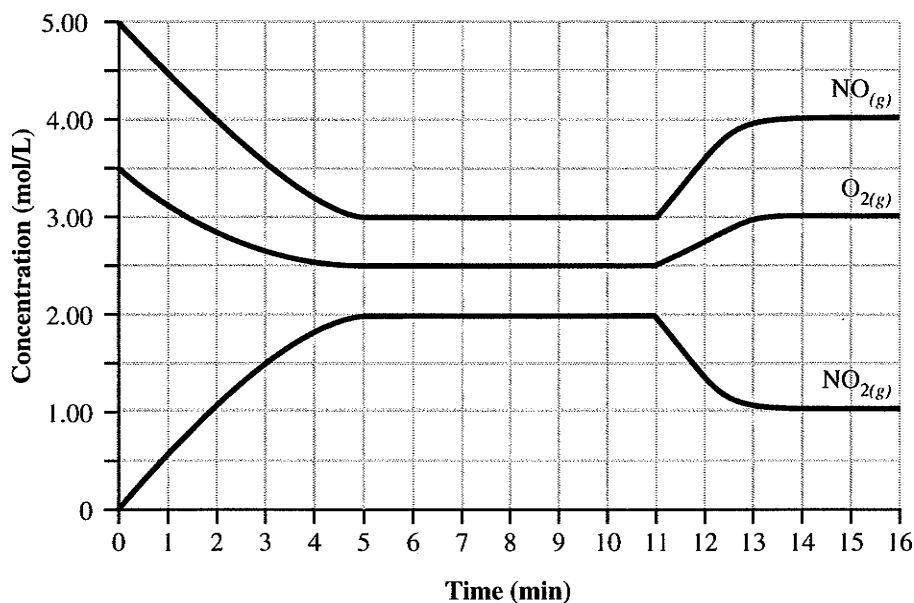
- 7.** As dry air at  $0.0^\circ\text{C}$  is heated to  $100.0^\circ\text{C}$ , it undergoes changes mainly in
- A.** kinetic energy
  - B.** potential energy
  - C.** potential and kinetic energy
  - D.** potential, kinetic, and nuclear energy

In industry, ammonia may be used to manufacture nitric acid through a process called the "Ostwald Process." The three important reactions involved in this process are summarized by the equations below.



In the reaction represented by equation I, a mixture of ammonia and air is passed through a platinum mesh that has been heated to 800°C.

The reaction represented by equation II can be studied in a closed system. A graph of the component concentrations in one such study is shown below.



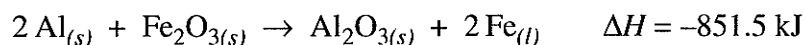
### Numerical Response

3. The energy required to increase the temperature of a 0.250 kg platinum mesh from 20.0°C to 800.0°C is \_\_\_\_\_ kJ.

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

8. In the study, equilibrium was attained after
- A. 4 min
  - B. 5 min
  - C. 11 min
  - D. 12 min
9. In the reaction represented by equation III, the yield of nitric acid could be increased by
- A. replacing the mesh in the system with small platinum pellets
  - B. decreasing the total pressure of the system by increasing the volume
  - C. increasing the total pressure of the system by decreasing the volume
  - D. adding  $\text{NO}_{(g)}$  to the system

A thermite reaction is a highly exothermic process that is used in welding massive steel objects such as ship propellers and train rails. The reaction can be represented by the equation



### Numerical Response

4. If the heat produced by the reaction of 1.00 mol of iron(III) oxide were absorbed by 7.40 kg of  $\text{H}_2\text{O}_{(l)}$  at room temperature, then the resulting temperature change of the water would be \_\_\_\_\_ °C.

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

### Numerical Response

5. The value of the oxidation number for

aluminum in  $\text{Al}_{(s)}$  is \_\_\_\_\_ (Record in the **first** column)

iron in  $\text{Fe}_2\text{O}_{3(s)}$  is \_\_\_\_\_ (Record in the **second** column)

aluminum in  $\text{Al}_2\text{O}_{3(s)}$  is \_\_\_\_\_ (Record in the **third** column)

iron in  $\text{Fe}_{(l)}$  is \_\_\_\_\_ (Record in the **fourth** column)

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

10. In this thermite reaction, the substance that undergoes oxidation is
- A. iron
  - B. aluminum
  - C. iron(III) oxide
  - D. aluminum oxide

Food manufacturers have designed a product that consists of a packaged meal and a stove. The stove, or “Food Heater,” consists of a water pouch, salt ( $\text{NaCl}_{(s)}$ ), iron, and magnesium. When water is added to the foam tray, the salt dissolves and a chemical reaction occurs, which heats the meal.

The diagrams that were present on the examination have not been included due to copyright restrictions. What follows is a description of the diagrams.

**Diagram 1** shows the components of the packaged meal on the food heater, both of which rest on a foam tray, a water pouch, and a cutlery pack.

**Diagram 2** shows the contents of the water pouch being added to the food heater beneath the meal.

**Diagram 3** shows the meal resting on the now activated food heater on the foam tray being returned to the food package.

—based on HeaterMeals Inc., 1995

11. The energy needed to heat the meal is **most likely** produced by a reaction between
- A.  $\text{Mg}_{(s)}$  and  $\text{H}_2\text{O}_{(l)}$
  - B.  $\text{Mg}_{(s)}$  and  $\text{NaCl}_{(s)}$
  - C.  $\text{Fe}_{(s)}$  and  $\text{H}_2\text{O}_{(l)}$
  - D.  $\text{Fe}_{(s)}$  and  $\text{Mg}_{(s)}$

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

The chemical reaction that occurs in the food heater raises the temperature of the 100 g of water in the pouch from 23.4°C to 71.7°C.

12. The amount of energy released by the food heater
- A. 4.83 kJ
  - B. 9.71 kJ
  - C. 9.81 kJ
  - D. 20.2 kJ
13. Which of the following statements describes the chemical reaction that raised the temperature of the water?
- A. An endothermic chemical reaction, which absorbs energy and increases the potential energy of the water, occurred.
  - B. An endothermic chemical reaction, which absorbs energy and increases the kinetic energy of the water, occurred.
  - C. An exothermic chemical reaction, which releases energy and increases the potential energy of the water, occurred.
  - D. An exothermic chemical reaction, which releases energy and increases the kinetic energy of the water, occurred.
- 
14. In the redox reaction that occurs in food heater, the  $\text{NaCl}_{(s)}$  that is dissolved in the water acts as
- A. an oxidizing agent
  - B. a reducing agent
  - C. an electrolyte
  - D. a buffer

15. From a technological perspective, the purpose of using a foam tray is to
- increase the specific heat capacity of the solution
  - provide a catalyst for the chemical reaction
  - reduce heat lost to the environment
  - reduce potential landfill waste

Use the following standard electrode potentials to answer the next question.

Reduction Half-Reaction	Electrical Potential (V)
$\text{PbO}_{2(s)} + \text{SO}_4^{2-}(aq) + 4\text{H}^+(aq) + 2\text{e}^- \rightarrow \text{PbSO}_{4(s)} + 2\text{H}_2\text{O}(l)$	+1.69
$\text{O}_{2(g)} + 2\text{H}_2\text{O}(l) + 4\text{e}^- \rightarrow 4\text{OH}^-(aq)$	+0.40
$\text{NiO}_{2(s)} + 2\text{H}_2\text{O}(l) + 2\text{e}^- \rightarrow \text{Ni(OH)}_{2(s)} + 2\text{OH}^-(aq)$	-0.49
$\text{Zn(OH)}_4^{2-}(aq) + 2\text{e}^- \rightarrow \text{Zn}_{(s)} + 4\text{OH}^-(aq)$	-1.20

16. In the half-reactions above, the strongest oxidizing agent is the
- $\text{PbO}_{2(s)}$ ,  $\text{SO}_4^{2-}(aq)$ , and  $\text{H}^+(aq)$  combination
  - $\text{O}_{2(g)}$  and  $\text{H}_2\text{O}(l)$  combination
  - $\text{Zn(OH)}_4^{2-}(aq)$
  - $\text{OH}^-(aq)$

Use the following standard electrode potentials to answer the next question.

Reduction Half-Reaction	Electrical Potential (V)
$X^{3+}_{(aq)} + 3e^{-} \rightarrow X_{(s)}$	+1.95
$Q_{(l)} + e^{-} \rightarrow Q^{-}_{(aq)}$	+0.61
$Y^{2+}_{(aq)} + e^{-} \rightarrow Y^{+}_{(aq)}$	+0.02
$M_{(s)} + 3e^{-} \rightarrow M^{3-}_{(aq)}$	-0.25

17. Which of the following tables identifies, with checkmarks (✓), the spontaneous reactions that would be predicted given the half-reactions shown above?

A.

	$X_{(s)}$	$Q^{-}_{(aq)}$	$Y^{+}_{(aq)}$	$M^{3-}_{(aq)}$
$X^{3+}_{(aq)}$	-	-	-	-
$Q_{(l)}$	✓	-	-	-
$Y^{2+}_{(aq)}$	✓	✓	-	✓
$M_{(s)}$	✓	✓	-	-

B.

	$X_{(s)}$	$Q^{-}_{(aq)}$	$Y^{+}_{(aq)}$	$M^{3-}_{(aq)}$
$X^{3+}_{(aq)}$	-	✓	✓	✓
$Q_{(l)}$	-	-	✓	✓
$Y^{2+}_{(aq)}$	-	-	-	✓
$M_{(s)}$	-	-	-	-

C.

	$X_{(s)}$	$Q^{-}_{(aq)}$	$Y^{+}_{(aq)}$	$M^{3-}_{(aq)}$
$X^{3+}_{(aq)}$	✓	✓	✓	-
$Q_{(l)}$	✓	✓	-	-
$Y^{2+}_{(aq)}$	✓	-	-	-
$M_{(s)}$	-	-	-	-

D.

	$X_{(s)}$	$Q^{-}_{(aq)}$	$Y^{+}_{(aq)}$	$M^{3-}_{(aq)}$
$X^{3+}_{(aq)}$	-	✓	✓	✓
$Q_{(l)}$	-	✓	✓	-
$Y^{2+}_{(aq)}$	-	✓	-	-
$M_{(s)}$	-	-	-	-

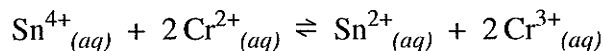


Use the following information to answer the next question.

Over 100 years ago, Gustave Eiffel designed the support structure for the Statue of Liberty. An iron framework was constructed and overlaid with copper sheets in such a way that the copper did not come into direct contact with the iron.

18. The Statue of Liberty's blue-green colour, which has developed over time, can be attributed to the
- A. oxidation of solid iron into iron(II) ions
  - B. oxidation of solid copper into copper(II) ions
  - C. reduction of solid iron and solid copper into cations
  - D. reduction of oxygen gas and liquid water into hydroxide ions
- 
19. It is estimated that up to 25% of the iron produced annually in North America is used to replace iron objects that have been damaged by rust. The corroded iron is often expensive or difficult to replace and is often disposed of in landfills. Corrosion is a concern from both
- A. a political and a scientific perspective
  - B. an ecological and an ethical perspective
  - C. a technological and a scientific perspective
  - D. an economic and an ecological perspective

Use the following equation to answer the next question.

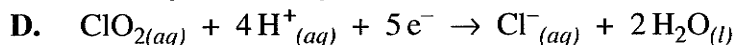
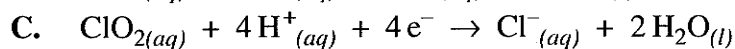
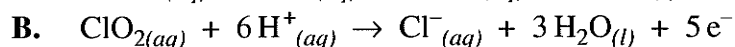
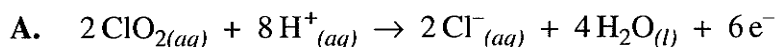


### Numerical Response

6. At standard conditions, the net potential for the reaction represented by the equation above is \_\_\_\_\_ V.

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

20. At API Grain Processors in Red Deer, Alberta, tanks used in the fermentation of wheat are sterilized using  $\text{ClO}_2(aq)$ . The balanced half-reaction that represents the change that occurs when  $\text{ClO}_2(aq)$  changes to  $\text{Cl}^-(aq)$  in an acidic solution is



21. Which of the following characteristics is associated with a voltaic cell consisting of standard half-cells of nickel and zinc?

A. The  $E^\circ_{\text{net}}$  is +1.02 V.

B. Cations migrate to the zinc electrode.

C. Oxidation occurs at the nickel electrode.

D. The net ionic equation is  $\text{Ni}^{2+}(aq) + \text{Zn}(s) \rightarrow \text{Ni}(s) + \text{Zn}^{2+}(aq)$ .

22. A student constructed a standard electrochemical cell by using copper metal and a copper(II) nitrate solution in one half-cell and an unlabelled metal and a nitrate solution of the metal ion in the other half-cell. The two half-cells were connected by a voltmeter, which then registered +0.79 V. If the copper electrode was the cathode, then the unlabelled metal electrode was likely

A. tin

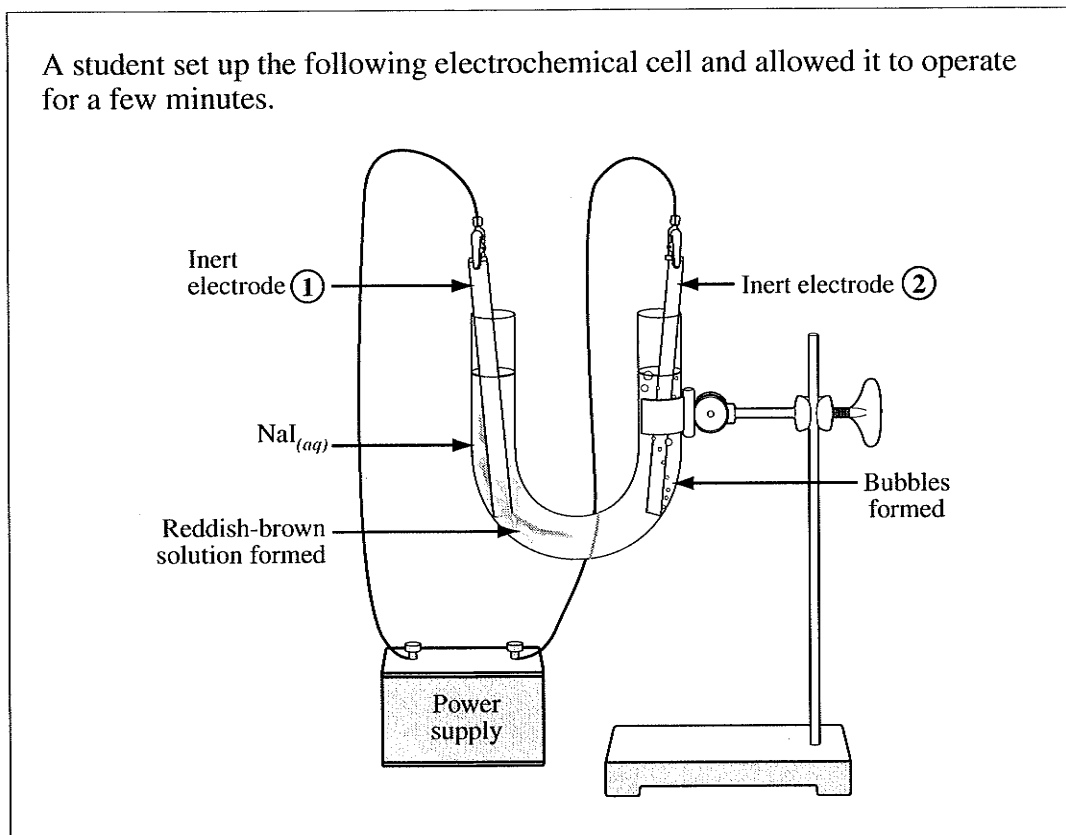
B. iron

C. silver

D. chromium

Use the following information to answer the next question.

A student set up the following electrochemical cell and allowed it to operate for a few minutes.

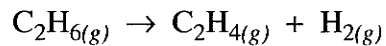


23. The gas formed near electrode 2 is **most likely**

- A.  $\text{I}_{2(g)}$
- B.  $\text{Na}_{(g)}$
- C.  $\text{O}_{2(g)}$
- D.  $\text{H}_{2(g)}$

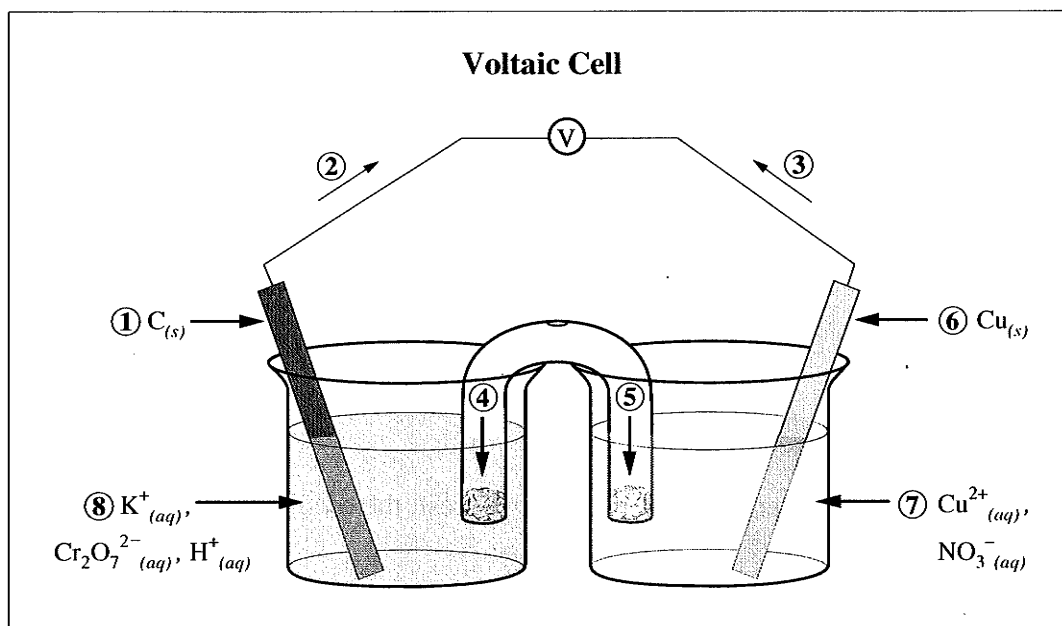
*Use the following information to answer the next question.*

Nova Chemicals is a major producer of ethene in Alberta. Ethene is produced by thermally cracking ethane that has been separated from natural gas. The following equation represents the cracking process.



24. In the cracking process, the oxidation number of
- A. carbon changes from  $-2$  to  $-3$
  - B. carbon changes from  $-3$  to  $-2$
  - C. hydrogen changes from  $0$  to  $+1$
  - D. hydrogen increases and decreases

Use the following diagram to answer the next question.



### Numerical Response

7. In the diagram above, the number that represents the
- anode is \_\_\_\_\_ (Record in the **first** column)
- cathode is \_\_\_\_\_ (Record in the **second** column)
- cation flow is \_\_\_\_\_ (Record in the **third** column)
- electron flow 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.

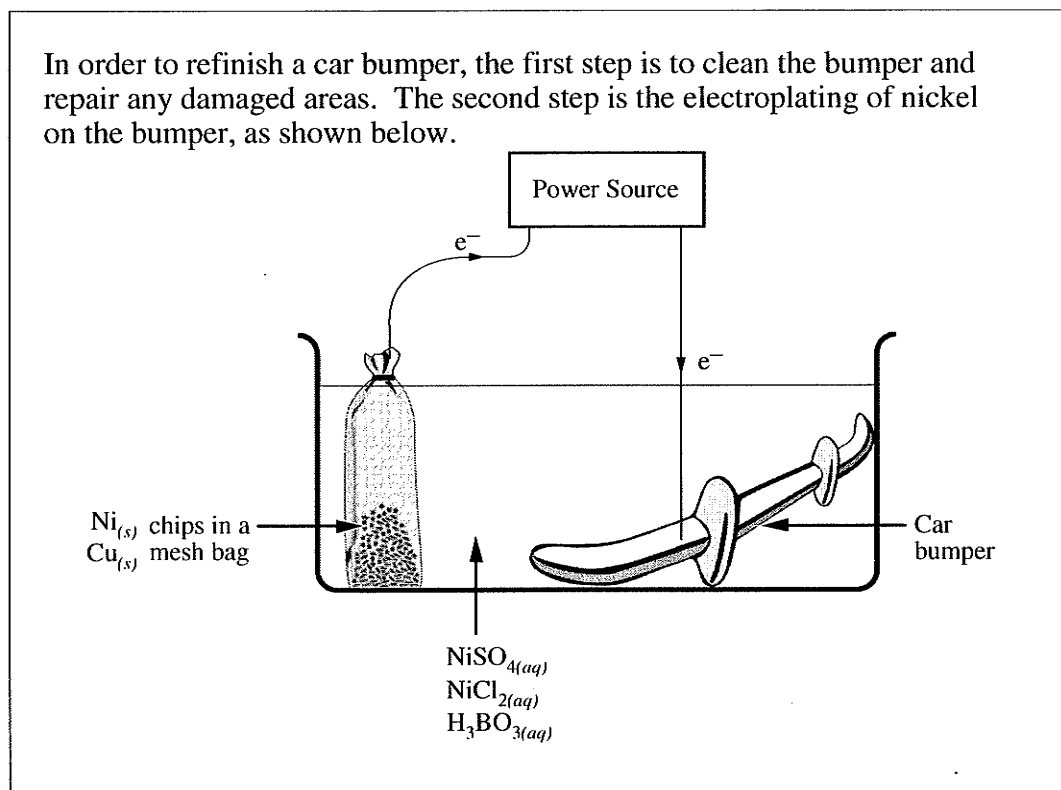
Four Reaction Equations	Key
$\text{In}_{(s)} + \text{La}^{3+}_{(aq)} \rightarrow \text{no reaction}$	<b>1</b> $\text{In}_{(s)}$ <b>5</b> $\text{In}^{3+}_{(aq)}$
$\text{Np}_{(s)} + \text{La}^{3+}_{(aq)} \rightarrow \text{Np}^{3+}_{(aq)} + \text{La}_{(s)}$	<b>2</b> $\text{Np}_{(s)}$ <b>6</b> $\text{Np}^{3+}_{(aq)}$
$\text{Np}_{(s)} + \text{Nd}^{3+}_{(aq)} \rightarrow \text{Np}^{3+}_{(aq)} + \text{Nd}_{(s)}$	<b>3</b> $\text{Nd}_{(s)}$ <b>7</b> $\text{Nd}^{3+}_{(aq)}$
$\text{La}_{(s)} + \text{Nd}^{3+}_{(aq)} \rightarrow \text{no reaction}$	<b>4</b> $\text{La}_{(s)}$ <b>8</b> $\text{La}^{3+}_{(aq)}$

### Numerical Response

- 8.** Arranged in order from strongest to weakest, the oxidizing agents above 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 two questions.



25. The reaction that would occur at the anode in the electroplating cell above is
- A.  $\text{Ni}_{(s)} \rightarrow \text{Ni}^{2+}_{(aq)} + 2e^-$
  - B.  $\text{Ni}^{2+}_{(aq)} + 2e^- \rightarrow \text{Ni}_{(s)}$
  - C.  $\text{Cu}_{(s)} \rightarrow \text{Cu}^{2+}_{(aq)} + 2e^-$
  - D.  $\text{SO}_4^{2-}_{(aq)} + \text{H}_2\text{O}_{(l)} + 2e^- \rightarrow \text{SO}_3^{2-}_{(aq)} + 2\text{OH}^-_{(aq)}$
26. In the third step of the electroplating process, the bumper is transferred to a tank that contains  $\text{CrSO}_{4(aq)}$ . A current of 3 750 A is used to plate a thin layer of chromium over the nickel. If the mass of the chromium layer is 125 g, then the time required for this plating process to occur is
- A. 0.515 min
  - B. 1.03 min
  - C. 2.06 min
  - D. 124 min

Use the following information to answer the next question.

In automobile engines, the high operating temperatures cause nitrogen and oxygen in the cylinders to combine to form toxic nitrogen monoxide. To simulate this process in a laboratory, nitrogen and oxygen are combined to form nitrogen monoxide in a closed system. After a period of time, there is evidence that nitrogen monoxide decomposes at the same rate as it forms.

27. This laboratory evidence can be communicated chemically as

- A.  $2\text{NO}_{(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{NO}_{2(g)}$
  - B.  $\text{N}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{NO}_{(g)}$
  - C.  $\text{N}_{2(g)} + \text{O}_{2(g)} \rightarrow 2\text{NO}_{(g)}$
  - D.  $\text{N}_{(g)} + \text{O}_{(g)} \rightleftharpoons \text{NO}_{(g)}$
- 

28. What type of solution could have a pH greater than 14?

- A. A dilute weak base
- B. A dilute strong base
- C. A concentrated strong base
- D. No solution could have a pH greater than 14



Use the following information to answer the next question.

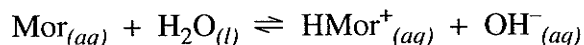
Exterminators sometimes use hydrogen cyanide gas to eliminate vermin such as rats from buildings. The deadly gas is produced by dissolving pellets of  $\text{NaCN}_{(s)}$  in  $\text{HCl}_{(aq)}$ .

29. A balanced net ionic equation for the reaction that produces this gas is

- A.  $\text{CN}^{-}_{(aq)} + 3\text{H}^{+}_{(aq)} + 2\text{e}^{-} \rightarrow \text{HCN}_{(g)} + \text{H}_{2(g)}$   
B.  $\text{NaCN}_{(s)} + \text{HCl}_{(aq)} \rightleftharpoons \text{HCN}_{(g)} + \text{NaCl}_{(aq)}$   
C.  $\text{CN}^{-}_{(aq)} + \text{H}_2\text{O}_{(l)} \rightleftharpoons \text{HCN}_{(g)} + \text{OH}^{-}_{(aq)}$   
D.  $\text{CN}^{-}_{(aq)} + \text{H}_3\text{O}^{+}_{(aq)} \rightleftharpoons \text{HCN}_{(g)} + \text{H}_2\text{O}_{(l)}$

Use the following information to answer the next question.

Morphine ( $\text{Mor}_{(aq)}$ ) is a narcotic prescribed to patients to diminish severe pain. Morphine can react with water, as represented by the equilibrium



30. A 0.100 mol/L sample of  $\text{Mor}_{(aq)}$  with a pH of 11.426 has a  $\text{OH}^{-}_{(aq)}$  concentration of

- A.  $3.75 \times 10^{-12}$  mol/L  
B.  $1.94 \times 10^{-6}$  mol/L  
C.  $2.67 \times 10^{-3}$  mol/L  
D.  $1.00 \times 10^{-1}$  mol/L

The disagreeable odour of rancid butter is caused in part by the presence of butanoic acid ( $\text{C}_3\text{H}_7\text{COOH}_{(aq)}$ ). The  $K_a$  value for  $\text{C}_3\text{H}_7\text{COOH}_{(aq)}$  at  $25^\circ\text{C}$  is  $1.5 \times 10^{-5}$ .

31. A characteristic of butanoic acid is that it is a
- A. strong acid
  - B. diprotic acid
  - C. weaker acid than ethanoic acid
  - D. stronger acid than phosphoric acid
32. The hydronium ion concentration in a  $0.10 \text{ mol/L } \text{C}_3\text{H}_7\text{COOH}_{(aq)}$  solution is
- A.  $1.2 \times 10^{-3} \text{ mol/L}$
  - B.  $1.5 \times 10^{-6} \text{ mol/L}$
  - C.  $7.5 \times 10^{-7} \text{ mol/L}$
  - D.  $6.7 \times 10^{-10} \text{ mol/L}$

Use your recorded answer from **Multiple Choice 32** to answer **Numerical Response 9**.\*

### Numerical Response

9. The pH of the  $0.10 \text{ mol/L } \text{C}_3\text{H}_7\text{COOH}_{(aq)}$  solution is \_\_\_\_\_.

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

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

33. The conjugate base of butanoic acid is
- A.  $\text{C}_3\text{H}_8\text{COOH}_{(aq)}$
  - B.  $\text{C}_3\text{H}_7\text{COOH}^+_{(aq)}$
  - C.  $\text{C}_3\text{H}_7\text{COO}_{(aq)}$
  - D.  $\text{C}_3\text{H}_7\text{COO}^-_{(aq)}$

34. If a solution of  $\text{C}_3\text{H}_7\text{COOH}_{(aq)}$  were to be titrated with  $\text{KOH}_{(aq)}$ , the **most suitable** indicator would be
- A. 1,3,5-trinitrobenzene
  - B. phenolphthalein
  - C. methyl orange
  - D. orange IV

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

Reagents			
1	$\text{Na}_2\text{CO}_{3(aq)}$	5	$\text{Na}_2\text{HPO}_{4(aq)}$
2	$\text{CaO}_{(aq)}$	6	$\text{CH}_3\text{COOH}_{(aq)}$
3	$\text{NaHCO}_{3(aq)}$	7	$\text{KOOCCOOH}_{(aq)}$
4	$\text{Ba}(\text{OH})_{2(aq)}$	8	$\text{NaHSO}_{3(aq)}$

### Numerical Response

10. Listed in numerical order, the reagents above that are amphiprotic are \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_.

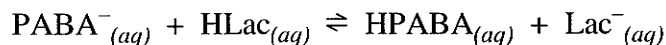
(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

HPABA (para-amino benzoic acid) is a weak acid whose salts are commonly used as a sunblock.  $\text{HPABA}_{(aq)}$  at  $25^\circ\text{C}$  has a  $K_a = 1.20 \times 10^{-5}$ .

35. If the concentration of  $\text{HPABA}_{(aq)}$  and the concentration of each of the following acids are the same, then the acid that would have a higher pH than  $\text{HPABA}_{(aq)}$  is
- A. nitric acid
  - B. benzoic acid
  - C. methanoic acid
  - D. hydrocyanic acid
36. The conjugate base of  $\text{HPABA}_{(aq)}$  is  $\text{PABA}^-_{(aq)}$ . The  $K_b$  of  $\text{PABA}^-_{(aq)}$  is
- A.  $1.20 \times 10^9$
  - B.  $5.00 \times 10^{-2}$
  - C.  $8.33 \times 10^{-10}$
  - D.  $1.20 \times 10^{-19}$

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

The  $\text{PABA}^-_{(aq)}$  in sunscreens may react with the lactic acid ( $\text{HLac}_{(aq)}$ ) found in perspiration. This reaction can be represented by the following equilibrium equation.



37. The Brønsted–Lowry acids in this equilibrium equation are
- A.  $\text{HLac}_{(aq)}$  and  $\text{Lac}^-_{(aq)}$
  - B.  $\text{PABA}^-_{(aq)}$  and  $\text{HLac}_{(aq)}$
  - C.  $\text{HLac}_{(aq)}$  and  $\text{HPABA}_{(aq)}$
  - D.  $\text{PABA}^-_{(aq)}$  and  $\text{HPABA}_{(aq)}$

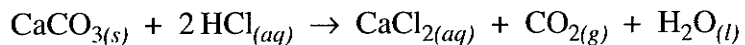
Use the following information to answer the next question.

Skin cancer may be caused by exposure to ultraviolet radiation. The intensity of ultraviolet radiation that reaches Earth has increased because of the thinning of the ozone layer. Medical research suggests that the use of sunscreens is beneficial in reducing the risk of skin cancer.

38. The statements above are presented from
- A. an economic perspective
  - B. a scientific perspective
  - C. a political perspective
  - D. an ethical perspective
39. Bromothymol blue indicator was added to a 100 mL sample of  $\text{HCl}_{(aq)}$ , which was then titrated with 10.0 mmol/L  $\text{NaOH}_{(aq)}$ . The endpoint was reached after the addition of 3.16 mL of  $\text{NaOH}_{(aq)}$ . The concentration of  $\text{HCl}_{(aq)}$  in the sample was
- A. 0.158 mmol/L
  - B. 0.316 mmol/L
  - C. 0.632 mmol/L
  - D. 31.6 mmol/L

Use the following information to answer the next question.

Antacids are bases that neutralize excess hydrochloric acid in the stomach. One brand of antacid tablet contains the active ingredient  $\text{CaCO}_{3(s)}$ . The other part of the tablet is filler. An equation for the neutralization reaction of this tablet is

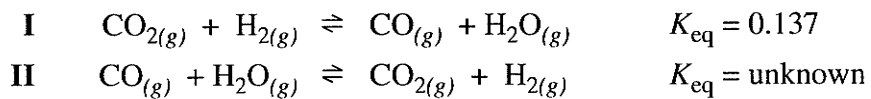


### Numerical Response

- 11.** The mass of  $\text{CaCO}_{3(s)}$  required to neutralize 15.0 mL of stomach acid that has a pH of 1.500 is \_\_\_\_\_ mg.

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

Use the following information to answer the next three questions.



40. If hydrogen gas is added to reaction I at equilibrium, then the concentration of the carbon dioxide and the value of the  $K_{\text{eq}}$  will
- A. decrease and stay the same, respectively
  - B. increase and stay the same, respectively
  - C. increase and decrease, respectively
  - D. decrease and increase, respectively
41. In reaction II, the  $K_{\text{eq}}$  is
- A. 0.137
  - B. -0.137
  - C. -7.30
  - D. 7.30

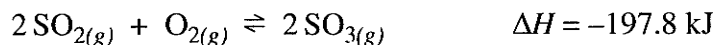
Use the following additional information to answer the next question.

Reaction I at Equilibrium			
$[\text{CO}_{2(g)}]$ mol/L	$[\text{H}_{2(g)}]$ mol/L	$[\text{CO}_{(g)}]$ mol/L	$[\text{H}_2\text{O}_{(g)}]$ mol/L
?	1.50	2.50	0.250

42. The concentration of  $\text{CO}_{2(g)}$  in reaction I at equilibrium is
- A. 0.0822 mol/L
  - B. 0.329 mol/L
  - C. 3.04 mol/L
  - D. 12.2 mol/L

Use the following information to answer the next question.

Sulfur dioxide gas reacts with oxygen to form sulfur trioxide gas, as represented by the equation



### Numerical Response

- 12.** In order to obtain the equilibrium system above, 2.60 mol of  $\text{SO}_{2(g)}$  and 2.30 mol of  $\text{O}_{2(g)}$  are injected into a 1.00 L container. When the system reaches equilibrium, the concentration of the remaining  $\text{SO}_{2(g)}$  is 1.32 mol/L. The concentration of  $\text{O}_{2(g)}$  at equilibrium is \_\_\_\_\_ mol/L.

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

- 43.** When carbonic acid in the blood dissociates, excess hydronium ions are excreted through the kidneys. In the kidneys, urine contains an  $\text{NH}_3(aq)/\text{NH}_4^+(aq)$  buffer. An equation that represents the reaction between the excess hydronium ions and the buffer is

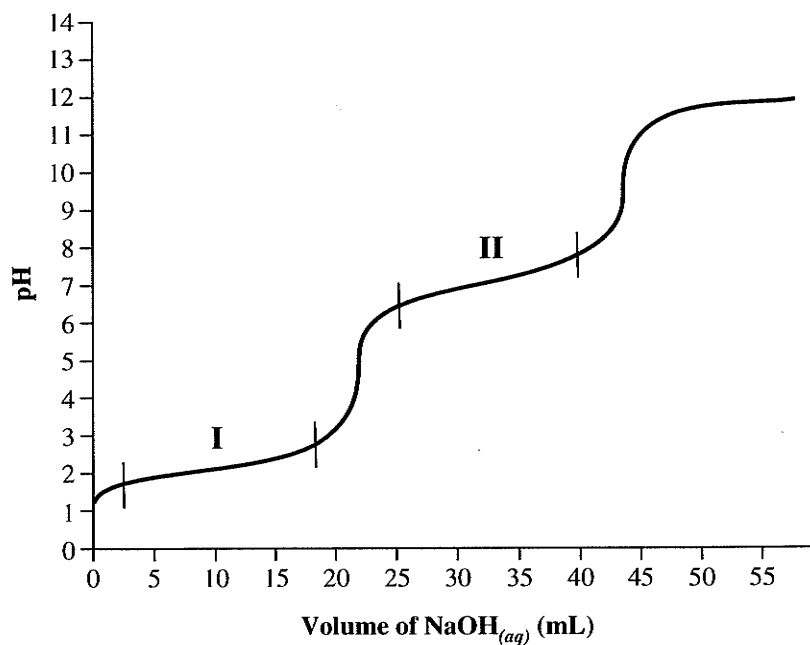
- A.  $\text{NH}_3(aq) + \text{H}_3\text{O}^+(aq) \rightleftharpoons \text{NH}_4^+(aq) + \text{H}_2\text{O}(l)$   
B.  $\text{NH}_4^+(aq) + \text{OH}^-(aq) \rightleftharpoons \text{NH}_3(aq) + \text{H}_2\text{O}(l)$   
C.  $\text{NH}_3(aq) + \text{H}_2\text{CO}_3(aq) \rightleftharpoons \text{NH}_4^+(aq) + \text{HCO}_3^-(aq)$   
D.  $\text{NH}_4^+(aq) + \text{HCO}_3^-(aq) \rightleftharpoons \text{NH}_3(aq) + \text{H}_2\text{CO}_3(aq)$



Use the following information to answer the next question.

The following pH curve represents the changes in pH during a titration of the weak diprotic acid  $\text{H}_2\text{A}_{(aq)}$  with a sodium hydroxide solution.

**Titration of  $\text{H}_2\text{A}_{(aq)}$  with  $\text{NaOH}_{(aq)}$**



(i) Chem30\_0102  
mc42

44. Regions I and II above represent the reaction of  $\text{NaOH}_{(aq)}$  with the primary species
- A.  $\text{H}_2\text{A}_{(aq)}$  and  $\text{HA}^-_{(aq)}$ , respectively
  - B.  $\text{H}_3\text{O}^+_{(aq)}$  and  $\text{HA}^-_{(aq)}$ , respectively
  - C.  $\text{HA}^-_{(aq)}$  and  $\text{A}^{2-}_{(aq)}$ , respectively
  - D.  $\text{H}_3\text{O}^+_{(aq)}$  and  $\text{A}^{2-}_{(aq)}$ , respectively

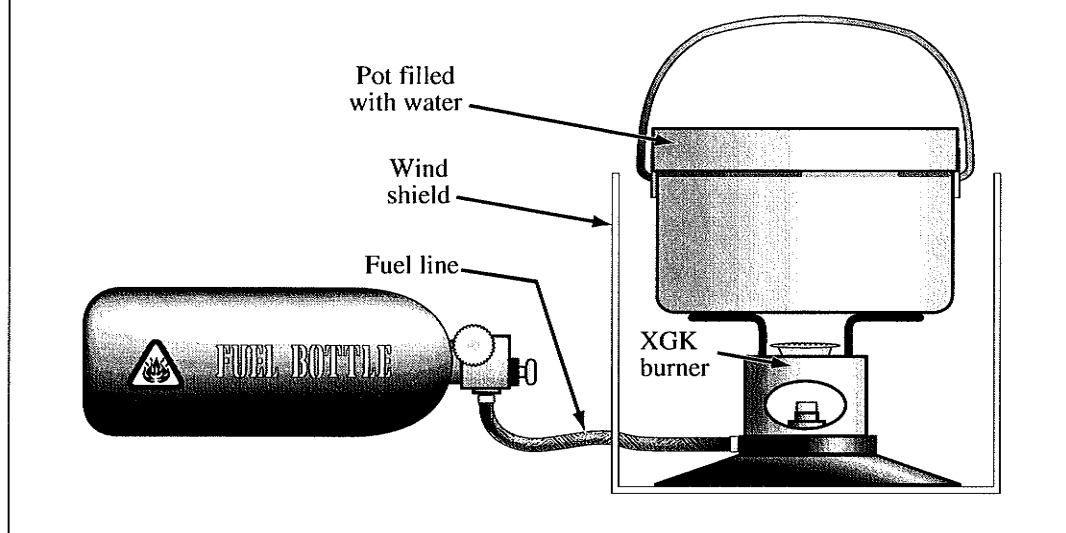
*The written-response questions follow on the next page.*



- c. The reduction potential for the  $\text{AuCl}_4^-$  (aq) half-reaction is 1.00 V. Suggest a substance that could be used to convert the  $\text{AuCl}_4^-$  (aq) back into  $\text{Au}$  (s). **Justify** your choice.

Use the following information to answer the next question.

Outdoor equipment manufacturer Mountain Safety Research of Seattle, Washington, manufactures a camping stove called the XGK Expedition Stove. The XGK can burn liquid fuels such as white gas, kerosene, diesel, naphtha, stoddart solvent, and gasoline.



**Written Response—15%**

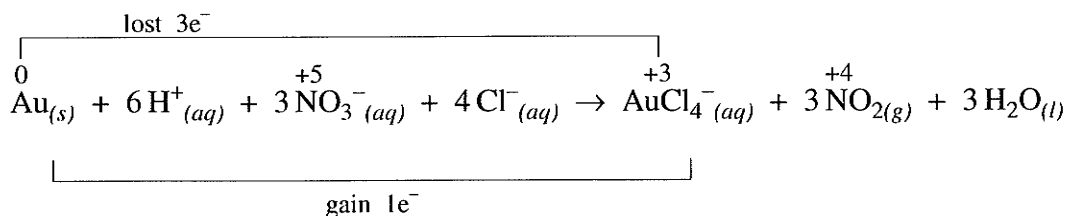
2. **Design** an experiment that would allow you to choose the best fuel for heating water on the XGK stove.

Your response should also include

- a detailed procedure
- the identity of all relevant variables
- another consideration for choosing a fuel

**Chemistry 30 Diploma Examination June 2003, Part A**  
**—Sample Solutions**

**1.a.**



Oxidizing agent is acidified  $\text{NO}_3^-_{(aq)}$  (or nitrogen). It gains  $1e^-$  per formula unit.  
 Reducing agent is  $\text{Au}_{(s)}$ . It loses  $3e^-$  per atom.

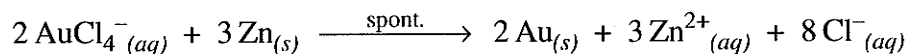
**b.**

$$\frac{225 \text{ g}}{196.97 \text{ g/mol}} = 1.14 \text{ mol Au}_{(s)}$$

$$1.14 \text{ mol Au}_{(s)} \times \frac{1 \text{ AuCl}_4^-_{(aq)}}{1 \text{ Au}_{(s)}} = 1.14 \text{ mol AuCl}_4^-_{(aq)}$$

$$\frac{1.14 \text{ mol}}{4.00 \text{ L}} = 0.286 \text{ mol/L AuCl}_4^-_{(aq)}$$

**c.** A possible substance is  $\text{Zn}_{(s)}$  because it is a reducing agent that lies below  $\text{AuCl}_4^-_{(aq)}$  (or  $E^\circ_{\text{net}}$  is positive) and therefore will react spontaneously with  $\text{AuCl}_4^-_{(aq)}$ .



Any reducing agent that lies below  $1.00 \text{ V}$  on the reduction potential table is acceptable provided it will react with the  $\text{AuCl}_4^-_{(aq)}$ .

\* Please note that this is only a sample response and other variations of the response may also have received full marks.

**2. Procedure (minimal):**

1. Obtain a fuel bottle with each type of fuel (white gas, kerosene, diesel, naphtha, Stoddart solvent, and gasoline).
2. Determine the mass of each bottle.
3. Put 1.00 kg of water into the pot and record the initial temperature of the water or the initial time. Place the pot filled with water on top of the stove.
4. Light fuel and burn until water in the pot reaches a set temperature ( $\approx 90\text{ }^{\circ}\text{C}$ ) or until boiling.
5. Turn off stove.
6. Record the final mass of the fuel bottle and maximum temperature of water or time to heat the water.
7. Repeat steps 3 to 6 for each bottle of fuel.

**Variables:**

- manipulated variable : the fuel being tested
- responding variable : the mass of fuel consumed
- controlled variable : same stove
  - same volume of water
  - same pot

**Selection Criteria:**

Another consideration is availability of the fuel. If you can only buy it in one store it is not very practical to use it. The cost of each fuel is another important consideration as well as operating temperature range, altitude range, energy density, etc.

\* Please note that this is only a sample response and other variations of the response may also have received full marks.

**Chemistry 30 Diploma Examination June 2003, Part B**  
**—Multiple-Choice and Numerical-Response Answers**

Key: MC—Multiple Choice; NR—Numerical Response

Question	Key	Diff. %*
MC1	B	71.4
MC2	D	88.3
MC3	A	81.6
NR1	5241 or 5242 or 5244	32.3
MC4	A	79.6
MC5	C	69.4
MC6	B	50.3
NR2	2.16*	54.0
MC7	A	76.7
NR3	25.9	74.3
MC8	B	90.2
MC9	C	64.1
NR4	27.5	55.2
NR5	0330	76.9
MC10	B	75.4
MC11	A	57.9
MC12	D	94.2
MC13	D	69.0
MC14	C	48.0
MC15	C	83.7
MC16	A	89.1
MC17	B	79.3
MC18	B	75.1
MC19	D	92.9
NR6	0.56	65.4
MC20	D	50.2
MC21	D	73.1
MC22	B	87.2

Question	Key	Diff. %*
MC23	D	42.7
MC24	B	89.8
NR7	6143	35.3
NR8	5876	45.8
MC25	A	66.4
MC26	C	47.4
MC27	B	88.1
MC28	C	53.2
MC29	D	57.9
MC30	C	80.2
MC31	C	76.4
MC32	A	59.7
NR9	2.91 or 2.92 <sup>†</sup>	75.1
MC33	D	92.0
MC34	B	52.8
NR10	3578	41.7
MC35	D	63.8
MC36	C	80.1
MC37	C	87.0
MC38	B	90.3
MC39	B	78.2
NR11	23.7	38.4
MC40	A	36.8
MC41	D	38.9
MC42	C	69.5
NR12	1.66	24.8
MC43	A	79.4
MC44	A	72.0

**Links:** \*If MC6 is A, then NR2 is 42.5  
 B, then NR2 is 2.16\*  
 C, then NR2 is 1.99  
 D, then NR2 is 1.96

\*Note: For NR2, 2.16 is always scored as correct regardless of the response to MC6.

<sup>†</sup>If MC32 is A, then NR9 is 2.91 or 2.92<sup>‡</sup>  
 B, then NR9 is 5.82  
 C, then NR9 is 6.12  
 D, then NR9 is 9.17 or 9.18

<sup>‡</sup>Note: For NR9, 2.91 or 2.92 is always scored as correct regardless of the response to MC32.

\*Difficulty—percentage of students answering the question correctly

