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Contents

Introduction

The questions presented in this booklet are from the November 2012 Chemistry 30 Diploma Examination. This material, along with the *Program of Studies*, the *Chemistry 30 Information Bulletin*, and the *2011-2012 Chemistry 30 Assessment Highlights*, 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 60 questions on the November 2012 Chemistry 30 Diploma Examination, all are being released. The statistics refer to the 139 students who wrote the examination in English in November 2012. These statistics must be interpreted with caution, as the population writing the November examination differs significantly from the populations writing in January or June.

Chemistry 30 Diploma Examination November 2012 Multiple-Choice and Numerical-Response Questions

1. *When methane gas is burned in a fireplace, the reaction that occurs is ___i___ . The original source of the energy stored in the methane gas is ___ii___ .*

The statements above are completed by the information in row

Row	*i*	*ii*
A.	endothermic	fossil fuel
B.	endothermic	the Sun
C.	exothermic	fossil fuel
D.	exothermic	the Sun

Use the following information to answer the next question.

Chemical Equations

1	$C(s) + 2\,H_2O(g) + 90.1\text{ kJ} \rightarrow CO_2(g) + 2\,H_2(g)$	
2	$CO(g) + H_2O(g) \rightarrow CO_2(g) + H_2(g) + 41.2\text{ kJ}$	
3	$C_2H_5OH(l) + 3\,O_2(g) \rightarrow 2\,CO_2(g) + 3\,H_2O(g)$	$\Delta H = -514.1\text{ kJ}$
4	$C_3H_8(g) + 6\,H_2O(g) \rightarrow 3\,CO_2(g) + 10\,H_2(g)$	$\Delta H = +374.1\text{ kJ}$

Numerical Response

1. When the equations numbered above are ordered from the reaction that **absorbs** the most energy per mole of carbon dioxide gas to the reaction that **releases** the most energy per mole of carbon dioxide gas, the order is

__________ , __________ , __________ , and __________ .

Most absorbed ... **Most released**

(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.

Aerospace engineers are interested in using hydrogen gas as fuel in airplanes because of its low density. Hydrogen gas can be produced by the reaction represented by the following overall equation.

$$CH_4(g) + 2\,H_2O(g) \xrightarrow{\text{metal catalyst}} CO_2(g) + 4\,H_2(g)$$

2. *The enthalpy change for the reaction represented by the equation above is ___i___ , and the enthalpy change per mole of hydrogen is ___ii___ .*

The statement above is completed by the information in row

Row	*i*	*ii*
A.	+164.7 kJ	+658.8 kJ/mol
B.	+164.7 kJ	+41.2 kJ/mol
C.	−77.1 kJ	−308.4 kJ/mol
D.	−77.1 kJ	−19.3 kJ/mol

Use the following information to answer the next question.

Much of the lead used for batteries and ammunition during the First World War and the Second World War came from galena, PbS(s). The following equations represent the reactions that are involved in refining galena to produce solid lead.

Equation I $2\,PbS(s) + 3\,O_2(g) \rightarrow 2\,PbO(s) + 2\,SO_2(g)$ $\Delta H° = -827.4$ kJ

Equation II $2\,C(s) + O_2(g) \rightarrow 2\,CO(g)$

Equation III $PbO(s) + CO(g) \rightarrow Pb(s) + CO_2(g)$

3. *In Equation I, the reactants have ___i___ energy than the products, and if energy were included as a term in the equation, it would be a ___ii___.*

The statement above is completed by the information in row

Row	*i*	*ii*
A.	less	reactant
B.	less	product
C.	more	reactant
D.	more	product

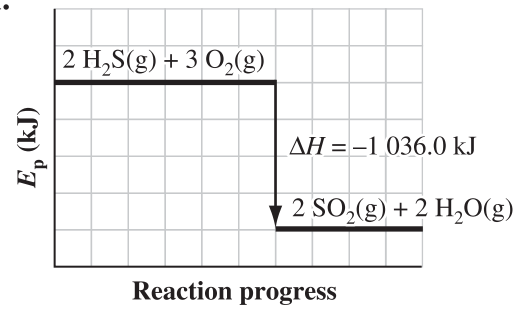
Use the following information to answer the next question.

Hydrogen sulfide gas undergoes a combustion reaction with oxygen to produce gaseous sulfur dioxide and water vapour.

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

4. The potential energy diagram, including the enthalpy change, associated with the combustion of hydrogen sulfide gas is

A.



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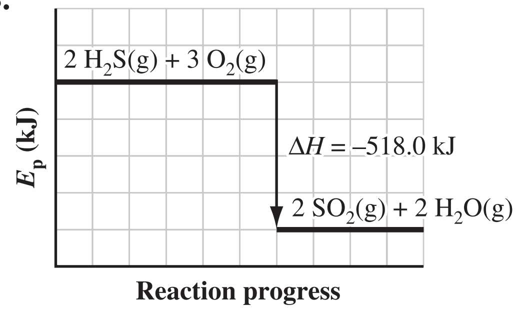

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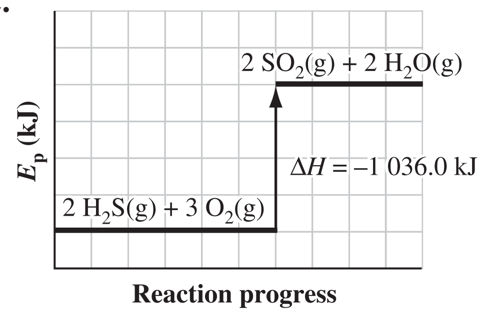

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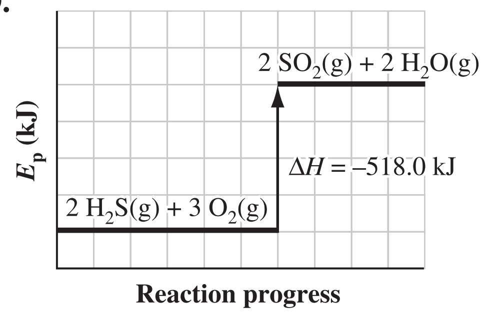
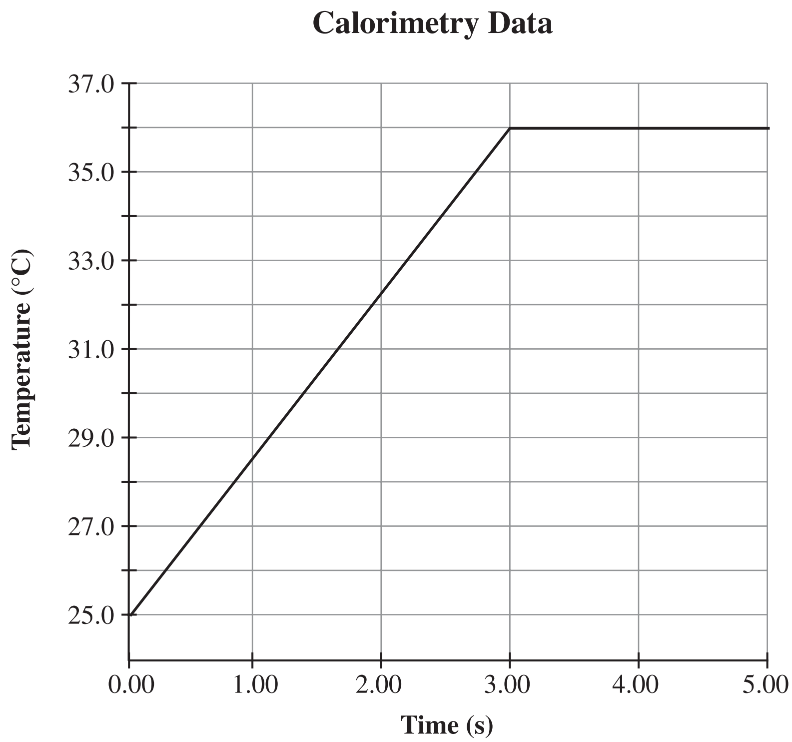


Use the following information to answer the next two questions.

A student mixed 50.0 mL of 1.00 mol/L HCl(aq) with 50.0 mL of 1.00 mol/L NaOH(aq) in a calorimeter. The final mass of the resulting solution was 100.0 g, and the change in temperature of the resulting solution was recorded over time, as shown in the graph below.



The student assumed that the specific heat capacity of the final solution was the same as that of water and that the calorimeter neither gained nor lost heat.

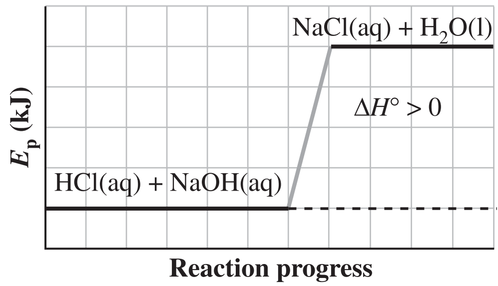
Numerical Response

2. The energy transferred to the resulting solution in the student's experiment was __________ kJ.

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

5. Which of the following potential energy diagrams represents the reaction that occurs during the student's experiment?

A.



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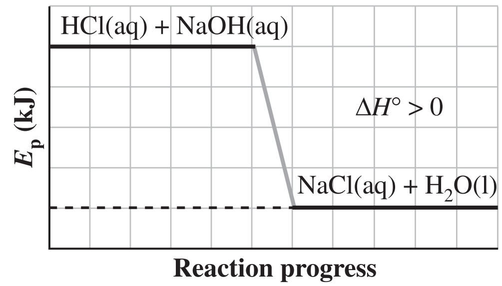
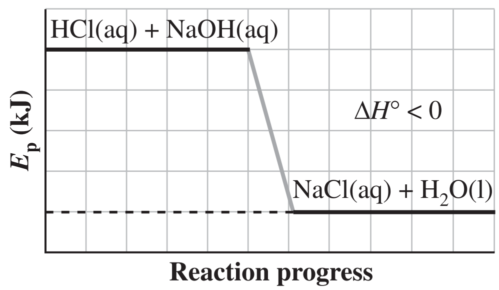
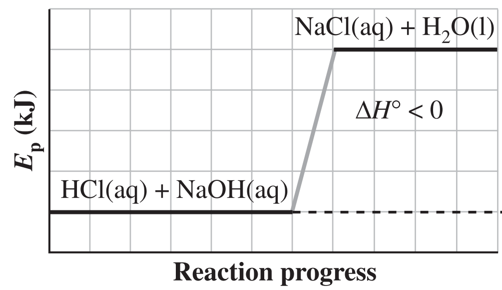


C.



D.



Use the following information to answer the next question.

A student was asked to design a calorimetry experiment to compare the enthalpy changes in kilojoules per mole when burning samples of equal mass of methanol and ethanol.

6. In the experiment, the student's variables should be listed such that the

A. manipulated variable is the type of fuel and the controlled variable is the temperature change

B. manipulated variable is the type of fuel and the responding variable is the temperature change

C. controlled variable is the type of fuel and the responding variable is the temperature change

D. controlled variable is the mass of fuel and the responding variable is the type of fuel

Use the following information to answer the next question.

A hand-warmer packet contains a mixture of powdered iron, carbon, sodium chloride, sawdust, and zeolite, all moistened by a little water. The packet is activated by removing the plastic cover, which exposes the materials in the packet to air. The reaction that occurs is represented by the following equation.

$$4\,Fe(s) + 3\,O_2(g) \rightarrow 2\,Fe_2O_3(s) + 1\,648.4\text{ kJ}$$

Numerical Response

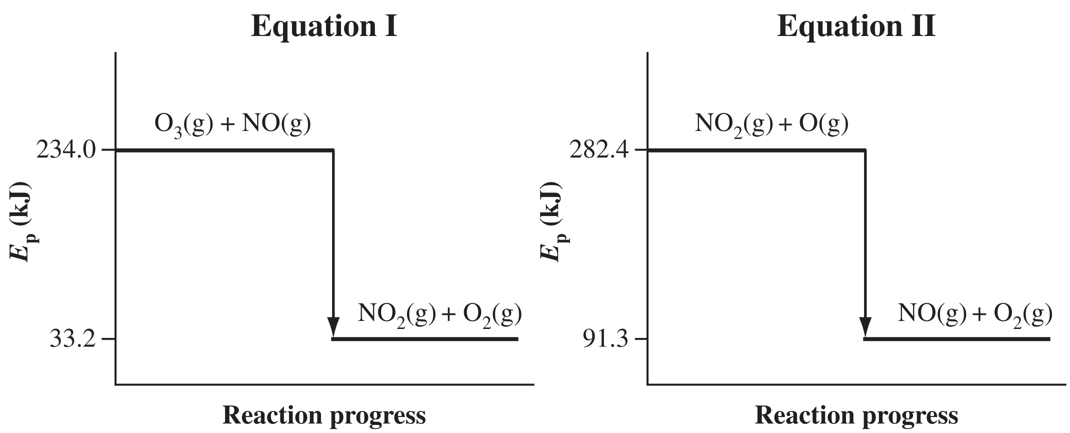
3. When 2.50 g of $Fe_2O_3(s)$ is produced in the hand-warmer packet, the energy transferred is __________ kJ.

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

Use the following information to answer the next two questions.

The ozone layer reduces the amount of ultraviolet radiation that reaches the surface of the Earth. In the upper atmosphere, ozone can be depleted by a two-step reaction, as represented by the following equations.

Equation I	$O_3(g) + NO(g) \rightarrow NO_2(g) + O_2(g)$
Equation II	$NO_2(g) + O(g) \rightarrow NO(g) + O_2(g)$
Overall Equation	$O_3(g) + O(g) \rightarrow 2\,O_2(g)$



7. The energy transferred during the reaction represented by the overall equation is

A. 9.7 kJ
B. 142.7 kJ
C. 249.2 kJ
D. 391.9 kJ

8. *In the reaction represented by Equation I, nitrogen monoxide gas undergoes* ___***i***___ *and the nitrogen atom in nitrogen monoxide* ___***ii***___ *electrons.*

The statement above is completed by the information in row

Row	*i*	*ii*
A.	reduction	gains
B.	reduction	loses
C.	oxidation	gains
D.	oxidation	loses

Use the following information to answer the next two questions.

Airbags in vehicles contain the chemicals sodium azide, $NaN_3(s)$, and iron(III) oxide. When activated by an electrical spark, the sodium azide decomposes rapidly and the gas produced causes the airbag to expand. The reactions that occur in the airbag are represented below.

Equation I $2\,NaN_3(s) \rightarrow 2\,Na(s) + 3\,N_2(g)$

Equation II $Na(s) \rightarrow Na(l)$ $\quad \Delta H = 2.61\text{ kJ}$

Equation III $6\,Na(l) + Fe_2O_3(s) \rightleftharpoons 3\,Na_2O(s) + 2\,Fe(s)$ $\quad \Delta H = -439.9\text{ kJ}$

9. If the molar enthalpy of formation for solid sodium azide is +21.7 kJ/mol, then the enthalpy change for the reaction represented by Equation I is

A. −43.4 kJ

B. −10.9 kJ

C. +10.9 kJ

D. +43.4 kJ

Numerical Response

4. In Equation III, the oxidation number for the metal in

$Na_2O(s)$ is ____________ (Record in the **first** column)

$Na(l)$ is ____________ (Record in the **second** column)

$Fe(s)$ is ____________ (Record in the **third** column)

$Fe_2O_3(s)$ 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.

Equations of Redox Reactions

I	$2\ Ce^{4+}(aq) + Pd(s) \rightarrow 2\ Ce^{3+}(aq) + Pd^{2+}(aq)$
II	$Pd^{2+}(aq) + 2\ In^{2+}(aq) \rightarrow Pd(s) + 2\ In^{3+}(aq)$
III	$Cd^{2+}(aq) + Pd(s) \rightarrow$ no reaction
IV	$In^{3+}(aq) + Cd(s) \rightarrow$ no reaction

10. The strongest oxidizing agent in the equations given above is

A. $Ce^{3+}(aq)$
B. $Ce^{4+}(aq)$
C. $Cd^{2+}(aq)$
D. $In^{3+}(aq)$

Use the following information to answer the next question.

Copper can undergo a series of reactions known as the cycle of copper. In this cycle, the initial copper reactant is changed into different compounds before being recovered as copper metal in the last step. The series of reactions is represented by the following equations.

Reactions in the Cycle of Copper

Equation I	$Cu(s) + 4\ HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2\ NO_2(g) + 2\ H_2O(l)$
Equation II	$Cu(NO_3)_2(aq) + 2\ NaOH(aq) \rightarrow Cu(OH)_2(s) + 2\ NaNO_3(aq)$
Equation III	$Cu(OH)_2(s) \rightarrow CuO(s) + H_2O(l)$
Equation IV	$CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$
Equation V	$CuSO_4(aq) + Zn(s) \rightarrow ZnSO_4(aq) + Cu(s)$

11. The oxidation–reduction reactions in the equations given above are

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

Use the following information to answer the next question.

Species

1	Al(s)	**5**	$Fe^{2+}(aq)$
2	$F_2(g)$	**6**	$Ni^{2+}(aq)$
3	AgI(s)	**7**	$O_2(g)$ and $H_2O(l)$
4	$H_2O(l)$		

Numerical Response

5. The species above that will oxidize $Cr^{2+}(aq)$ are numbered _____, _____, _____, and _____.

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

Use the following information to answer the next question.

Volcanoes on Jupiter's moons emit hydrogen sulfide gas and sulfur dioxide gas. These gases react to form gaseous products, as represented by the following equation.

$$16\,H_2S(g) + 8\,SO_2(g) \rightarrow 16\,H_2O(g) + 3\,S_8(g)$$

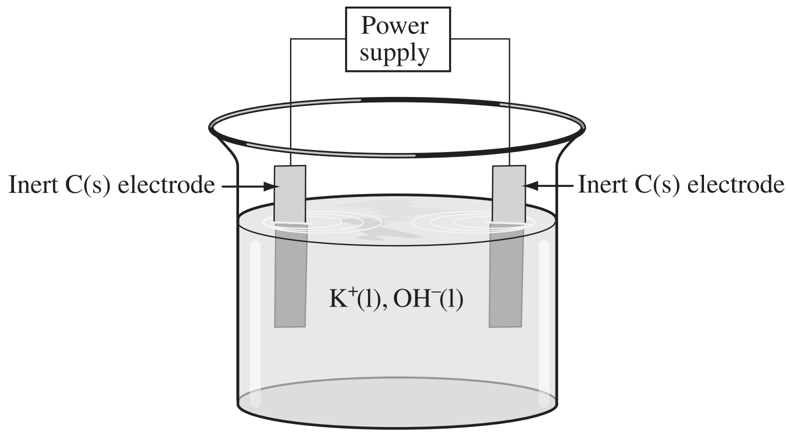
12. Which of the following rows identifies the reducing agent and the substance being oxidized when the gases react?

Row	Reducing Agent	Substance Being Oxidized
A.	$H_2S(g)$	$H_2S(g)$
B.	$H_2S(g)$	$SO_2(g)$
C.	$SO_2(g)$	$H_2S(g)$
D.	$SO_2(g)$	$SO_2(g)$

Use the following information to answer the next two questions.

Metallic potassium was first prepared by Humphry Davy in 1807 by the electrolysis of molten potassium hydroxide at a temperature of 410 °C.

Electrochemical Cell



13. *In the electrochemical cell above, the calculated $E°_{cell}$ value is ___**i**___ , and the reaction is ___**ii**___ .*

The statement above is completed by the information in row

Row	*i*	*ii*
A.	positive	spontaneous
B.	positive	nonspontaneous
C.	negative	spontaneous
D.	negative	nonspontaneous

14. The equation that represents the reaction that occurs at the cathode is

A. $K^+(l) + e^- \rightarrow K(l)$

B. $2\,H_2O(l) + 2\,e^- \rightarrow H_2(g) + 2\,OH^-(aq)$

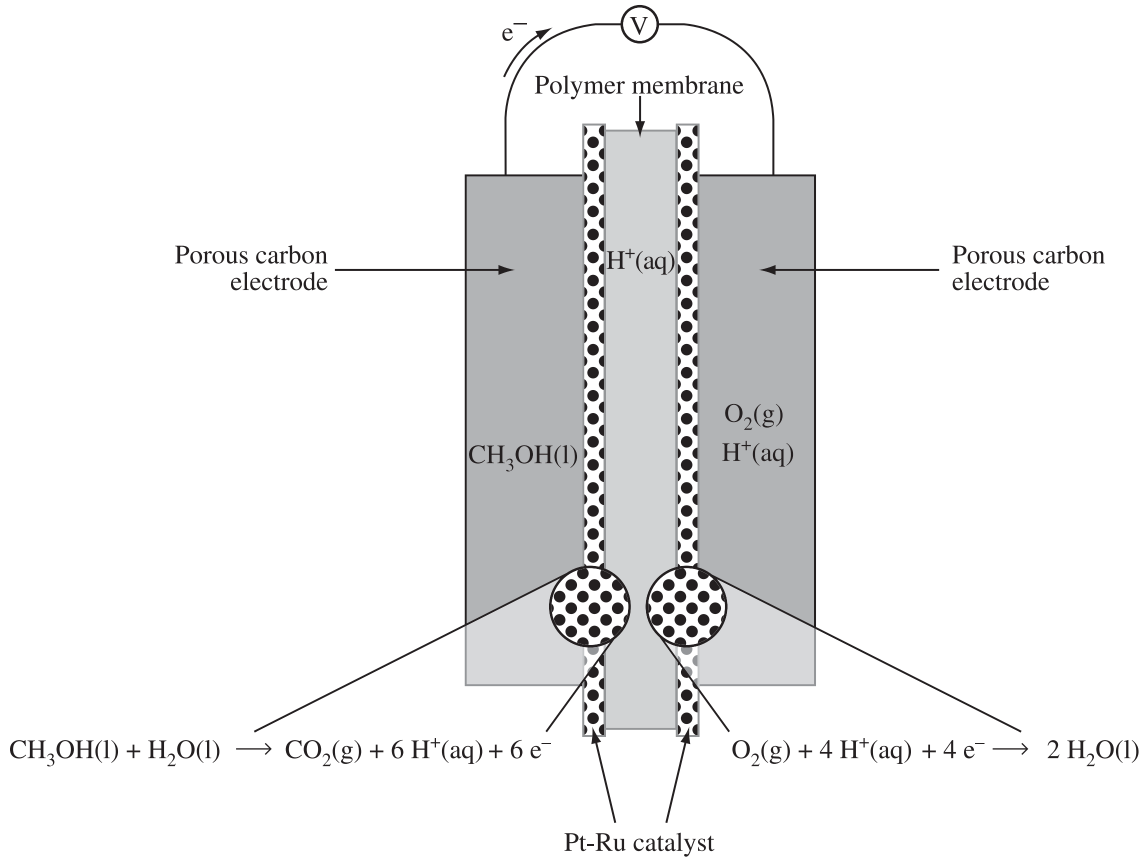
C. $H_2(g) + 2\,OH^-(aq) \rightarrow 2\,H_2O(l) + 2\,e^-$

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

Use the following information to answer the next two questions.

Methanol fuel cells produce electricity by reacting methanol and oxygen gas from the air. A simplified diagram of a methanol fuel cell is shown below.

Methanol Fuel Cell



Numerical Response

6. When the equation for the overall reaction in the methanol fuel cell is balanced with the lowest whole number coefficients, the coefficient for

$O_2(g)$ is __________ (Record in the **first** column)

$H_2O(l)$ is __________ (Record in the **second** column)

$CO_2(g)$ is __________ (Record in the **third** column)

$CH_3OH(l)$ is __________ (Record in the **fourth** column)

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

Numerical Response

7. If the cell potential for the methanol fuel cell is +0.80 V, then the reduction potential for the half-reaction involving $CH_3OH(l) + H_2O(l)$ will be +/–__________ V.

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

Use the following information to answer the next question.

Magnesium is a lightweight, abundant, and relatively inexpensive metal often used for cathodic protection. Magnesium is produced by the electrolysis of molten magnesium chloride derived from sea water, as represented by the following equation.

$$MgCl_2(l) \rightarrow Mg(l) + Cl_2(g)$$

Numerical Response

8. If 0.893 mol of $Cl_2(g)$ is produced at one electrode of the electrolytic cell, then the mass of Mg(l) produced at the other electrode is __________ g.

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

Use the following information to answer the next two questions.

The concentration of vitamin C, $C_6H_8O_6(aq)$, in a sample of grapefruit juice can be measured by titration with an aqueous iodine solution, using starch as an indicator. When unreacted iodine is present, the starch forms a purple complex. The titration reaction is represented by the following equation.

$$C_6H_8O_6(aq) + I_2(aq) \rightarrow C_6H_6O_6(aq) + 2\,H^+(aq) + 2\,I^-(aq)$$

In an experiment to determine the vitamin C concentration in grapefruit juice, a student titrates 10.00 mL samples of grapefruit juice with a 0.100 mol/L $I_2(aq)$ solution. The student records the following data.

Volume of $I_2(aq)$ Used During the Titration

Trial	**I**	**II**	**III**	**IV**
Final burette reading (mL)	29.69	49.12	29.51	48.93
Initial burette reading (mL)	10.17	29.69	10.00	29.51

15. The concentration of vitamin C in the grapefruit juice is

A. 5.14×10^{-2} mol/L

B. 9.74×10^{-2} mol/L

C. 1.95×10^{-1} mol/L

D. 3.89×10^{-1} mol/L

Use the following additional information to answer the next question.

Statements Related to the Titration

1 The indicator changes colour at the endpoint.
2 The grapefruit juice should be placed in the burette.
3 The grapefruit juice should be placed in the Erlenmeyer flask.
4 The sample should be measured with a pipette.
5 The sample should be measured with a graduated cylinder.
6 The iodine undergoes reduction.
7 The iodine undergoes disproportionation.

Numerical Response

9. The statements above that apply to this titration are numbered _____, _____, _____, and _____.

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

Use the following information to answer the next two questions.

The lead storage battery is the most common battery used in automobiles. The half-reactions that occur in a cell of the battery during discharge are represented by the following equations.

Reactions that Occur in the Lead Storage Battery

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

Equation II $Pb(s) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + 2\,e^-$

16. *During discharge of the lead storage battery, ____**i**____ move toward the cathode and the species at the cathode ____**ii**____ electrons.*

The statement above is completed by the information in row

Row	***i***	***ii***
A.	anions	loses
B.	anions	gains
C.	cations	loses
D.	cations	gains

Numerical Response

10. In a cell in the lead storage battery above, the $E°_{cell}$ 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.

Reduction Half-Reactions

$Am^{4+}(aq) + e^- \rightleftharpoons Am^{3+}(aq)$	$E° = +2.60$ V
$Tl^{3+}(aq) + 2\,e^- \rightleftharpoons Tl^{+}(aq)$	$E° = +1.25$ V
$Ac^{3+}(aq) + 3\,e^- \rightleftharpoons Ac(s)$	$E° = -2.20$ V
$Cs^{+}(aq) + e^- \rightleftharpoons Cs(s)$	$E° = -3.03$ V

Species

1	$Am^{4+}(aq)$	**5**	$Am^{3+}(aq)$
2	$Tl^{3+}(aq)$	**6**	$Tl^{+}(aq)$
3	$Ac^{3+}(aq)$	**7**	$Ac(s)$
4	$Cs^{+}(aq)$	**8**	$Cs(s)$

Numerical Response

11. Match the species numbered above with the descriptors given below.

Species that will react spontaneously with $Tl^{+}(aq)$ __________ (Record in the **first** column)

Reducing agent that will **not** react spontaneously with $Cl_2(g)$ __________ (Record in the **second** column)

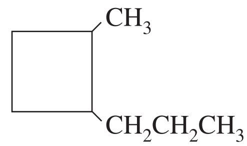
Reducing agent that is stronger than Ca(s) __________ (Record in the **third** column)

Oxidizing agent that is stronger than $MnO_4^{-}(aq) + \mathbf{8}\,H^{+}(aq)$ __________ (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.

A student drew the structural diagram shown below.



17. The compound represented by the structural diagram that the student drew can be described as an

A. aliphatic alkane containing a three-carbon parent

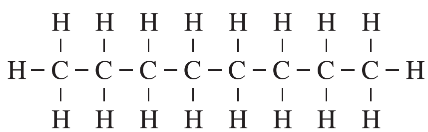
B. aromatic compound containing a four-carbon ring structure

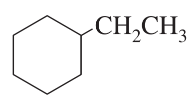
C. alkane containing a double-bonded four-carbon ring structure

D. alkane containing a four-carbon parent with only single bonds

Use the following additional information to answer the next question.

Compounds that Contain Eight Carbons

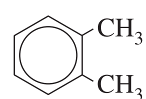
1 

5 

2 oct-3-ene

6 2,3-dimethyl-1-propylcyclopropane

3 2,3-dimethylhex-2-ene

7 

4 3,3-dimethylhexane

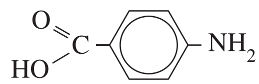
Numerical Response

12. The compounds above that are isomers of the structural diagram that the student drew are numbered _____, _____, _____, and _____.

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

Use the following information to answer the next question.

Sunscreens may contain para-aminobenzoic acid (PABA). The PABA in the sunscreen absorbs ultraviolet (UV) radiation from the Sun, which can cause damage to the skin. After swimming, a person must reapply a sunscreen containing PABA because PABA is water soluble. PABA is represented by the structural diagram below.



18. *PABA can be classified as an ____i____ organic compound that is ____ii____ .*

The statement above is completed by the information in row

Row	*i*	*ii*
A.	aliphatic	an alcohol
B.	aliphatic	a carboxylic acid
C.	aromatic	an alcohol
D.	aromatic	a carboxylic acid

Use the following information to answer the next question.

The following table gives the boiling points of three alcohols.

Alcohol	Boiling Point (°C)
butan-1-ol	117.7
butan-2-ol	99.0
2-methyl-propan-2-ol	82.4

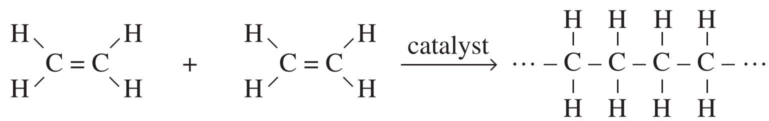
19. *Using **only** information contained in the table above, when the alcohols in the table are compared, they have the same ____i____ formula, but different ____ii____ properties.*

The statement above is completed by the information in row

Row	*i*	*ii*
A.	molecular	chemical
B.	molecular	physical
C.	structural	chemical
D.	structural	physical

Use the following information to answer the next two questions.

Ethene is produced in the petrochemical industry and is used as an intermediate in the manufacture of other chemicals, especially plastics. With the use of a catalyst, ethene molecules can be linked together to form polyethene, a widely used plastic, as represented by the following equation.



20. Ethene is classified as

A. aromatic

B. saturated

C. unsaturated

D. halogenated

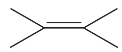
21. *Ethene is a* ___***i***___ *and is converted to polyethene by* ___***ii***___ *reaction.*

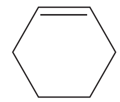
The statement above is completed by the information in row

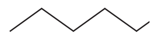
Row	*i*	*ii*
A.	monomer	an esterification
B.	monomer	a polymerization
C.	polymer	an esterification
D.	polymer	a polymerization

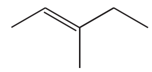
Use the following information to answer the next three questions.

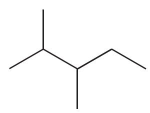
Line Diagrams for Selected Organic Compounds

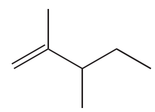
I 

IV 

II 

V 

III 

VI 

22. The line diagrams above that represent structural isomers are

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

23. The IUPAC name for compound III is

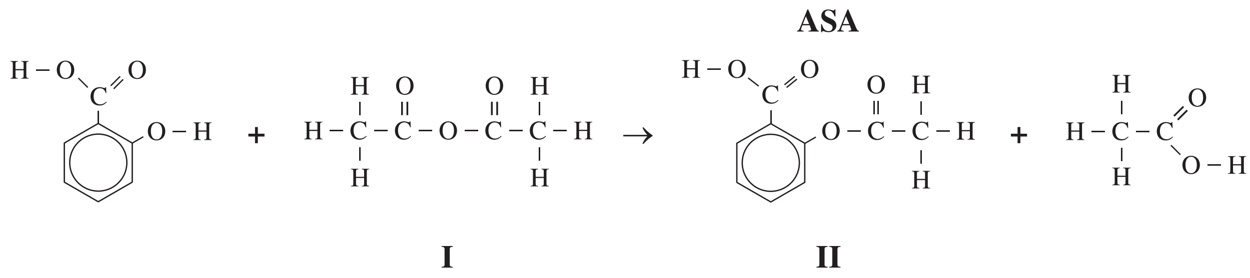
A. 3,4-dimethylpentane
B. 2,3-dimethylpentane
C. 3-ethyl-2-methylbutane
D. 1,1-dimethyl-2-ethylpropane

24. If aqueous bromine is added, in the absence of light, to samples of the compounds in the diagrams above, the compounds that would cause the bromine solution to lose its colour are

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

Use the following information to answer the next question.

Acetylsalicylic acid, commonly known as ASA, can be used to relieve pain, lower fever, and reduce swelling. The production of ASA is represented by the following equation.



25. *In the production of ASA represented by the equation above, molecule I is* ___***i***___ *, and molecule II can be classified as an* ___***ii***___ *.*

The statement above is completed by the information in row

Row	***i***	***ii***
A.	aliphatic	ester
B.	aliphatic	alcohol
C.	aromatic	ester
D.	aromatic	alcohol

Use the following information to answer the next question.

PVC, polyvinyl chloride, is a hard plastic used to make sewage pipes and vinyl siding. The monomer, vinyl chloride, is produced in a two-step process as represented by the following equations.

Equations

$$\textbf{I} \qquad C_2H_4(g) + Cl_2(g) \xrightarrow{\text{catalyst}} C_2H_4Cl_2(l)$$

$$\textbf{II} \qquad C_2H_4Cl_2(l) \xrightarrow{\text{heat, pressure}} C_2H_3Cl(g) + HCl(g)$$

26. *The reaction represented by Equation I is* ___***i***___ *reaction and the product is an* ___***ii***___ .

The statement above is completed by the information in row

Row	***i***	***ii***
A.	an addition	alkene
B.	an addition	alkyl halide
C.	a substitution	alkene
D.	a substitution	alkyl halide

Use the following information to answer the next three questions.

Hydrogen cyanide, HCN(g), a poisonous and volatile gas, is used in the manufacture of dyes and explosives. It is produced by the reaction represented by the following equation.

$$CH_4(g) + NH_3(g) + 255.6\ kJ \rightarrow HCN(g) + 3\,H_2(g)$$

27. The molar enthalpy of formation of gaseous hydrogen cyanide is

A. +376.1 kJ/mol

B. +135.1 kJ/mol

C. −135.1 kJ/mol

D. −376.1 kJ/mol

28. *During the production of hydrogen cyanide gas, energy is ___**i**___ the surroundings, and hydrogen atoms are ___**ii**___ .*

The statement above is completed by the information in row

Row	*i*	*ii*
A.	released to	reduced only
B.	released to	reduced and oxidized
C.	absorbed from	reduced only
D.	absorbed from	reduced and oxidized

Use the following additional information to answer the next question.

Hydrogen cyanide forms a weak acid solution when mixed with water, as represented by the following equation.

$$HCN(aq) + H_2O(l) \rightleftharpoons CN^-(aq) + H_3O^+(aq)$$

Numerical Response

13. The pH of a solution of 0.20 mol/L HCN(aq) 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.

$$4\,HCl(g) + O_2(g) \rightleftharpoons 2\,H_2O(g) + 2\,Cl_2(g) + 114.4\text{ kJ}$$

29. *In the reaction represented by the equation above, oxygen gas acts as the ___**i**___ agent and its oxidation number ___**ii**___.*

The statement above is completed by the information in row

Row	***i***	***ii***
A.	oxidizing	decreases
B.	oxidizing	increases
C.	reducing	decreases
D.	reducing	increases

30. Which of the following changes would increase the amount of chlorine gas present at equilibrium?

A. Adding a catalyst to the system

B. Decreasing the concentration of $O_2(g)$

C. Decreasing the temperature of the system

D. Increasing the volume of the reaction chamber

Use the following information to answer the next question.

Toluene, $C_7H_8(g)$, is an important organic solvent and can be produced as represented by the following equilibrium equation.

$$C_7H_{14}(g) + \text{energy} \rightleftharpoons C_7H_8(g) + 3\,H_2(g)$$

A technician placed 3.00 mol of $C_7H_{14}(g)$ into an empty 1.00 L flask. The flask was then stoppered and allowed to reach equilibrium. At equilibrium, 1.20 mol of $H_2(g)$ was present in the flask.

31. The value of the equilibrium constant is

A. 0.185

B. 0.266

C. 0.798

D. 1.15

Use the following information to answer the next question.

The equilibrium system for a soft drink in a sealed bottle can be represented by the following equation.

$$CO_2(g) + H_2O(l) \rightleftharpoons H_2CO_3(aq) + \text{energy}$$

32. *When the soft drink bottle is cooled by placing it in a refrigerator, the equilibrium will shift to produce more* __**i**__ *, and the value of* K_c *for the system will* __**ii**__ .

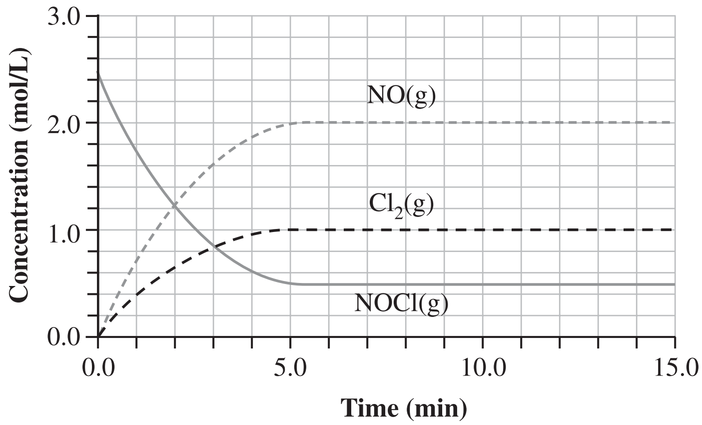
The statement above is completed by the information in row

Row	*i*	*ii*
A.	$CO_2(g)$	increase
B.	$CO_2(g)$	decrease
C.	$H_2CO_3(aq)$	increase
D.	$H_2CO_3(aq)$	decrease

Use the following information to answer the next two questions.

In a closed container, a pure sample of nitrosyl chloride, NOCl(g), undergoes an endothermic partial decomposition to produce nitrogen monoxide gas and chlorine gas at 25 °C, as represented by the diagram below.

Establishing an NOCl(g) Equilibrium System



33. *The equation that represents the forward reaction in this equilibrium system is* ___***i***___ *, and the equilibrium law expression is* ___***ii***___ *.*

The statement above is completed by the information in row

Row	*i*	*ii*
A.	$NOCl(g) \rightleftharpoons NO(g) + Cl_2(g)$	$K_c = \frac{[NO(g)][Cl_2(g)]}{[NOCl(g)]}$
B.	$NOCl(g) \rightleftharpoons NO(g) + Cl_2(g)$	$K_c = \frac{[NO(g)] + [Cl_2(g)]}{[NOCl(g)]}$
C.	$\mathbf{2}\,NOCl(g) \rightleftharpoons \mathbf{2}\,NO(g) + Cl_2(g)$	$K_c = \frac{[NO(g)]^2[Cl_2(g)]}{[NOCl(g)]^2}$
D.	$\mathbf{2}\,NOCl(g) \rightleftharpoons \mathbf{2}\,NO(g) + Cl_2(g)$	$K_c = \frac{2[NO(g)][Cl_2(g)]}{2[NOCl(g)]}$

Use the following additional information to answer the next question.

Statements

1 The concentration of $Cl_2(g)$ will increase.

2 The concentration of NO(g) will remain constant.

3 The number of moles of NOCl(g) will decrease.

4 The number of moles of NOCl(g) will stay the same.

5 The pressure in the container will increase.

6 The pressure in the container will remain constant.

7 The rate of the forward reaction is the same as the rate of the reverse reaction.

8 The rate of the forward reaction is greater than the rate of the reverse reaction.

Numerical Response

14. The statements above that apply to the NOCl(g) equilibrium system at 10.0 min are numbered _____, _____, _____, and _____.

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

---

34. Solid citric acid was added to a flask containing water and then stoppered. Which of the following observations would indicate that an equilibrium had been established?

A. The mass of solid citric acid remaining in the flask is constant.

B. The mass of solid citric acid is completely dissolved.

C. The forward and reverse reactions have stopped.

D. The pressure of the system is constant.

Use the following information to answer the next question.

Hydrogen sulfide gas, which is the cause of the odour of rotten eggs, can be produced from the anaerobic breakdown of wastes. To reduce this odour in sewers, municipalities can add sodium hypochlorite to the hydrogen sulfide dissolved in the waste water.

35. *The balanced Brønsted–Lowry equation that represents the reaction of aqueous hydrogen sulfide and aqueous sodium hypochlorite is* ___***i***___ *, and the reaction favours the* ___***ii***___ *.*

The statement above is completed by the information in row

Row	***i***	***ii***
A.	$H_2S(aq) + 2\,NaOCl(aq) \rightleftharpoons 2\,HOCl(aq) + Na_2S(aq)$	reactants
B.	$H_2S(aq) + 2\,NaOCl(aq) \rightleftharpoons 2\,HOCl(aq) + Na_2S(aq)$	products
C.	$H_2S(aq) + OCl^-(aq) \rightleftharpoons HS^-(aq) + HOCl(aq)$	reactants
D.	$H_2S(aq) + OCl^-(aq) \rightleftharpoons HS^-(aq) + HOCl(aq)$	products

Use the following information to answer the next question.

$$H_2SO_3(aq) + F^-(aq) \rightleftharpoons HSO_3^-(aq) + HF(aq)$$

36. *In the reaction represented by the equation above, the Brønsted–Lowry base is* ___***i***___ *and its conjugate acid is* ___***ii***___ *.*

The statement above is completed by the information in row

Row	***i***	***ii***
A.	$H_2SO_3(aq)$	$HF(aq)$
B.	$H_2SO_3(aq)$	$HSO_3^-(aq)$
C.	$F^-(aq)$	$HF(aq)$
D.	$F^-(aq)$	$HSO_3^-(aq)$

Use the following information to answer the next question.

Ascorbic acid, a powerful antioxidant in the human body, can be isolated from citrus fruits, rose hips, or spruce needles. Ascorbic acid ionizes in water, as represented by the following equation.

$$H_2C_6H_6O_6(aq) + H_2O(l) \rightleftharpoons HC_6H_6O_6^-(aq) + H_3O^+(aq)$$

37. *Ascorbic acid is classified as* ___***i***___ *, and its conjugate base* ___***ii***___ .

The statement above is completed by the information in row

Row	*i*	*ii*
A.	monoprotic	is amphiprotic
B.	monoprotic	can accept one proton
C.	polyprotic	is amphiprotic
D.	polyprotic	can donate two protons

Use the following information to answer the next question.

Acids

I	Methylammonium ion	$CH_3NH_3^+(aq)$	$K_a = 2.3 \times 10^{-11}$
II	Ammonium ion	$NH_4^+(aq)$	$K_a = 5.6 \times 10^{-10}$

38. *The ammonium ion is a* ___***i***___ *acid than the methylammonium ion because it has a* ___***ii***___ *value of* K_a.

The statement above is completed by the information in row

Row	*i*	*ii*
A.	weaker	larger
B.	weaker	smaller
C.	stronger	larger
D.	stronger	smaller

Use the following information to answer the next question.

A student prepares four solutions using oxalic acid, aqueous hydrogen oxalate ions, and aqueous oxalate ions.

Descriptions of the Four Solutions

Solution	Contents
1	Predominantly 1.0 mol/L $HOOCCOO^{-}(aq)$
2	Predominantly 1.0 mol/L $OOCCOO^{2-}(aq)$
3	Equal concentrations of 1.0 mol/L $HOOCCOOH(aq)$ and 1.0 mol/L $HOOCCOO^{-}(aq)$
4	Equal concentrations of 1.0 mol/L $HOOCCOO^{-}(aq)$ and 1.0 mol/L $OOCCOO^{2-}(aq)$

Numerical Response

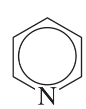
15. When listed in order from **lowest** pH to **highest** pH, the order of the solutions above is

__________ , __________ , __________ , and __________ .
Lowest pH **Highest pH**

(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.

Pyridine, $C_5H_5N(l)$, is an aromatic organic compound that is a base and is widely used as a solvent. Pyridine is represented by the structural diagram below.



39. The Brønsted–Lowry conjugate acid to pyridine is

A. $C_5H_5NH^{+}$

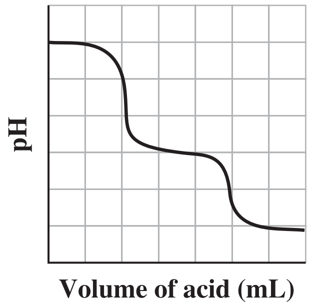
B. $C_5H_5N^{-}$

C. $C_4H_4N_2$

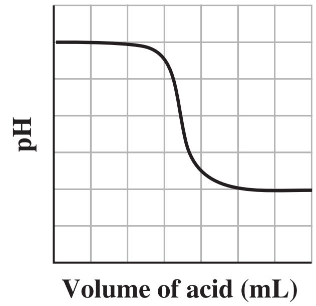
D. C_6H_6

40. Which of the following graphs can represent the titration of aqueous sulfurous acid, $H_2SO_3(aq)$, with aqueous sodium hydroxide?

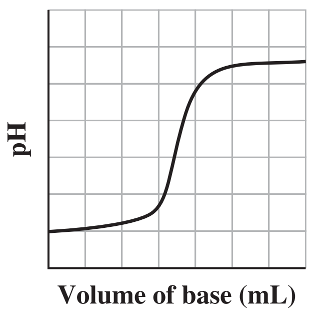
A.



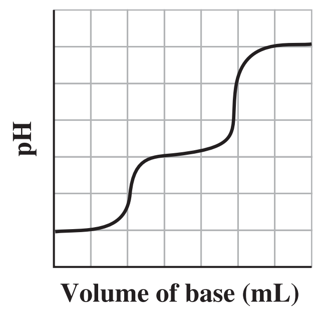
B.



C.



D.



41. Which of the following 0.10 mol/L solutions has the lowest pH?

A. HF(aq)

B. $H_3PO_4(aq)$

C. $H_2SO_3(aq)$

D. HOOCCOOH(aq)

Use the following information to answer the next question.

Pairs of Solutions

I	1.0 mol/L HCl(aq) and 1.0 mol/L NaOH(aq)
II	1.0 mol/L $HClO_4$(aq) and 1.0 mol/L $KClO_4$(aq)
III	1.0 mol/L H_2SO_4(aq) and 1.0 mol/L $LiHSO_4$(aq)
IV	1.0 mol/L H_3PO_4(aq) and 1.0 mol/L NaH_2PO_4(aq)

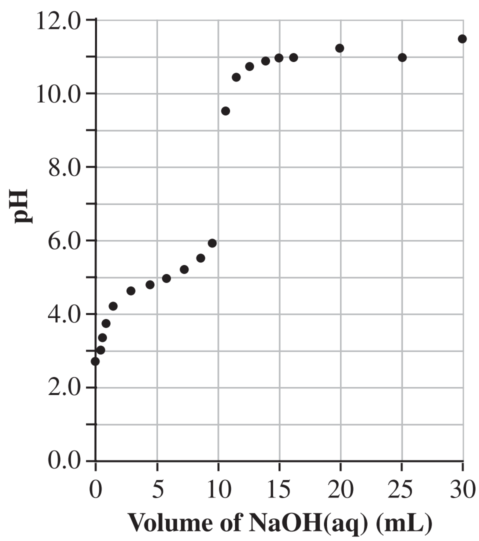
42. If each pair of solutions listed above is mixed together in equal volumes, then the pair of solutions that could act as a buffer is numbered

A. I
B. II
C. III
D. IV

Use the following information to answer the next question.

A tablet containing an unknown acid was dissolved to make 100.0 mL of solution. The entire solution was then titrated with 0.20 mol/L NaOH(aq), and the data were collected and then graphed, as shown below.

Titration of an Unknown Acid with NaOH(aq)



43. According to the pH curve above, the acid found in the tablet could be classified as a

A. monoprotic strong acid

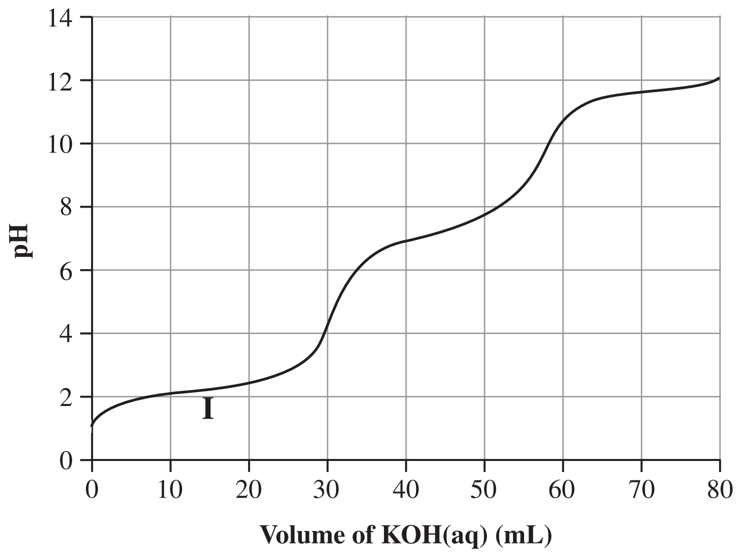
B. monoprotic weak acid

C. diprotic strong acid

D. diprotic weak acid

Use the following information to answer the next two questions.

Titration of Oxalic Acid with Potassium Hydroxide



44. The conjugate acid–base pair that occurs at section I on the diagram above is

A. HOOCCOOH(aq) and $HOOCCOO^-$(aq)

B. $HOOCCOO^-$(aq) and $OOCCOO^{2-}$(aq)

C. HOOCCOOH(aq) and OH^-(aq)

D. $HOOCCOO^-$(aq) and H_2O(l)

Numerical Response

16. In the net ionic equation that represents the reaction when the acid is completely neutralized, the coefficient for

H_2O(l) is __________ (Record in the **first** column)

OH^-(aq) is __________ (Record in the **second** column)

$OOCCOO^{2-}$(aq) is __________ (Record in the **third** column)

HOOCCOOH(aq) is __________ (Record in the **fourth** column)

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

Chemistry 30 Diploma Examination November 2012 Multiple-Choice and Numerical-Response Answers

Key: MC–Multiple Choice; NR–Numerical Response

Question	Key	*Diff. %	Question	Key	*Diff. %
MC1	D	51.8	**MC19**	B	42.4
NR1	4123	77.0	**MC20**	C	82.0
MC2	B	77.7	**MC21**	B	83.5
MC3	D	55.4	**MC22**	A	51.1
MC4	A	75.5	**MC23**	B	95.7
NR2	4.61	56.8	**MC24**	A	60.4
MC5	C	46.0	**MC25**	A	62.6
MC6	B	60.4	**MC26**	B	79.9
NR3	12.9	55.4	**MC27**	B	54.7
MC7	D	74.8	**MC28**	C	54.7
MC8	D	74.1	**NR13**	4.95	35.3
MC9	A	45.3	**MC29**	A	66.2
NR4	1003	68.3	**MC30**	C	69.1
MC10	B	84.2	**MC31**	B	44.6
MC11	B	51.1	**MC32**	C	50.4
NR5	2367 (any order)	60.4	**MC33**	C	81.3
MC12	A	61.9	**NR14**	2467 (any order)	77.0
MC13	D	66.2	**MC34**	A	38.8
MC14	A	50.4	**MC35**	D	57.6
NR6	3422	51.8	**MC36**	C	87.8
NR7	0.43	29.5	**MC37**	C	53.2
NR8	21.7	70.5	**MC38**	C	76.3
MC15	C	70.5	**NR15**	3142	20.1
NR9	1346 (any order)	37.4	**MC39**	A	82.0
MC16	D	72.7	**MC40**	D	59.7
NR10	2.05	60.4	**MC41**	D	59.7
NR11	1581	47.5	**MC42**	D	54.0
MC17	D	70.5	**MC43**	B	48.9
NR12	2356 (any order)	40.3	**MC44**	A	76.3
MC18	D	85.6	**NR16**	2211	41.0

*Difficulty–percentage of students answering the question correctly