Chemistry 30 | Released Items

2012 Released Diploma Examination Items

Government of Alberta

Alberta

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Contents

Introduction

The questions presented in this booklet are from the August 2012 Chemistry 30 Diploma Examination. This material, along with the *Program of Studies*, the *2012–2013 Subject Bulletin*, and the *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 August 2012 Chemistry 30 Diploma Examination, all are being released. The statistics refer to the 602 students who wrote the examination in English or in French in August 2012. These statistics must be interpreted with caution, as the population writing the August examination differs significantly from the populations writing in January or June.

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

1. *The balanced equation that represents the combustion of ethanol is* ___***i***___ *and the sign of the enthalpy change for the reaction is* ___***ii***___ .

The statement above is completed by the information in row

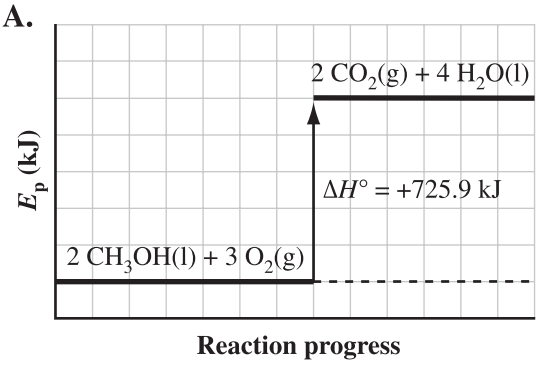
Row	*i*	*ii*
A.	$C_2H_5OH(l) + 3\,O_2(g) \rightarrow 2\,CO_2(g) + 3\,H_2O(g)$	negative
B.	$C_2H_5OH(l) + 3\,O_2(g) \rightarrow 2\,CO_2(g) + 3\,H_2O(g)$	positive
C.	$2\,C_2H_5OH(l) + 7\,O_2(g) \rightarrow 4\,CO_2(g) + 6\,H_2O(g)$	negative
D.	$2\,C_2H_5OH(l) + 7\,O_2(g) \rightarrow 4\,CO_2(g) + 6\,H_2O(g)$	positive

Use the following information to answer the next question.

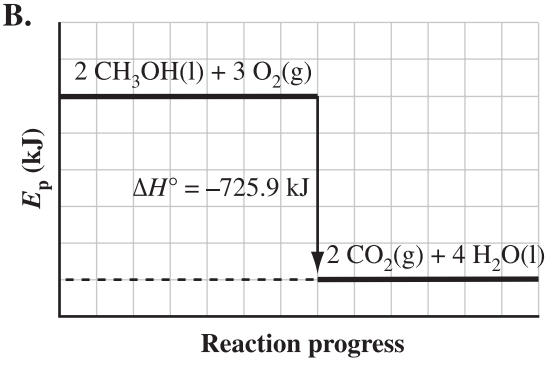
Methanol is used as fuel in racing cars. The energy content of methanol can be determined by calorimetry in a closed system.

2. Which of the following diagrams represents the combustion of methanol in a closed system?

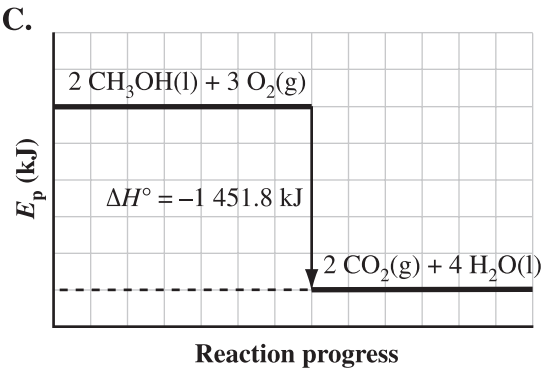
A.



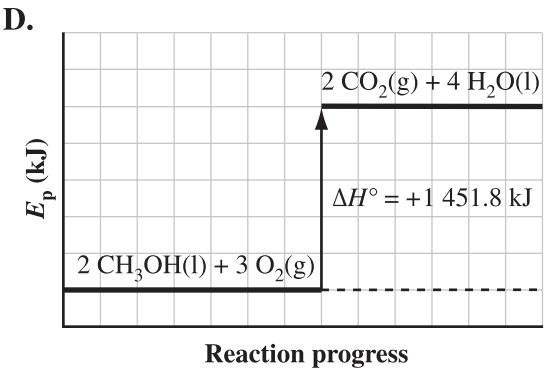
B.



C.



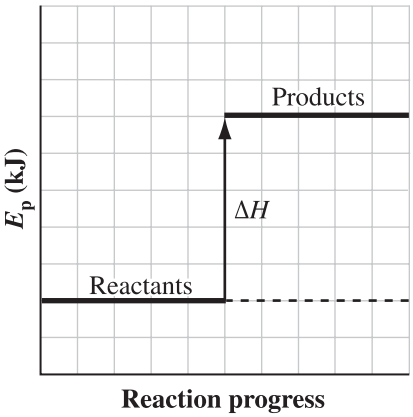
D.



Use the following information to answer the next question.

Reactions

1	Formation of carbon monoxide	$\Delta H° = -110.5$ kJ/mol
2	Formation of nitrogen monoxide	$\Delta H° = +91.3$ kJ/mol
3	Decomposition of hydrogen peroxide	$\Delta H° = -187.8$ kJ/mol
4	Decomposition of dinitrogen tetroxide	$\Delta H° = +11.1$ kJ/mol
5	$Mn(s) + O_2(g) \rightarrow MnO_2(s) + 520$ kJ	
6	$2\,Ga(s) + O_2(g) + 559$ kJ $\rightarrow 2\,GaO(g)$	
7	$F_2(g) + O_2(g) \rightarrow F_2O_2(g)$	$\Delta H° = +19.2$ kJ/mol
8	$N_2O_5(g) \rightarrow N_2(g) + \frac{5}{2}O_2(g)$	$\Delta H° = -13.3$ kJ/mol



Numerical Response

1. The enthalpy diagram above could be used to represent the reactions 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.

$$2\,Al(l) + 3\,NiO(l) \rightarrow Al_2O_3(s) + 3\,Ni(l) + 954\ kJ$$

3. The molar enthalpy of reaction for NiO(l) in the reaction represented by the equation above is

A. +954 kJ/mol

B. +318 kJ/mol

C. −318 kJ/mol

D. −954 kJ/mol

Use the following information to answer the next question.

Some drag-racing vehicles burn methanol, as represented by the following equation.

$$2\,CH_3OH(l) + 3\,O_2(g) \rightarrow 2\,CO_2(g) + 4\,H_2O(g) \qquad \Delta H = -1\,275.8\ kJ$$

Numerical Response

2. The mass of methanol that burns to produce an enthalpy change of -9.00×10^4 kJ is _____ kg.

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

Use the following information to answer the next question.

In an experiment, technicians compared the use of methane and propane as fuels. They burned samples of the two fuels and used a calorimeter to determine the energy transferred. The combustion reactions are represented by the following equations.

$$CH_4(g) + \mathbf{2}\,O_2(g) \rightarrow CO_2(g) + \mathbf{2}\,H_2O(g)$$

$$C_3H_8(g) + \mathbf{5}\,O_2(g) \rightarrow \mathbf{3}\,CO_2(g) + \mathbf{4}\,H_2O(g)$$

4. Which of the following statements correctly classifies two of the variables in the technicians' experiment?

A. The manipulated variable is the type of fuel, and a controlled variable is the type of calorimeter.

B. The responding variable is the final temperature of the water, and a controlled variable is the type of fuel.

C. The manipulated variable is the type of fuel, and a responding variable is the temperature change of the fuel.

D. The responding variable is the final temperature of the water, and a controlled variable is the temperature change of the fuel.

Use the following information to answer the next question.

The reactions for photosynthesis and cellular respiration are represented by the following equations.

Photosynthesis

$$6\,CO_2(g) + 6\,H_2O(l) + \text{energy} \rightarrow C_6H_{12}O_6(aq) + 6\,O_2(g)$$

Cellular Respiration

$$C_6H_{12}O_6(aq) + 6\,O_2(g) \rightarrow 6\,CO_2(g) + 6\,H_2O(l) + \text{energy}$$

5. Which of the following statements accurately describes photosynthesis and cellular respiration?

A. The products of photosynthesis have less potential energy than the reactants, whereas in cellular respiration, the reactants have less potential energy than the products.

B. Photosynthesis traps energy in the form of glucose, and cellular respiration absorbs energy required by all organisms.

C. Photosynthesis is an exothermic process, and cellular respiration is an endothermic process.

D. Photosynthesis requires energy, and cellular respiration produces energy.

Use the following information to answer the next two questions.

Sucrose, $C_{12}H_{22}O_{11}(s)$, is commonly used to sweeten food. In order to determine the molar enthalpy of combustion for sucrose, a technician burns a 0.015 0 mol sample of sucrose using a copper calorimeter that contains 250.0 g of water. The combustion of sucrose is represented by the following equation.

$$C_{12}H_{22}O_{11}(s) + 12\,O_2(g) \rightarrow 12\,CO_2(g) + 11\,H_2O(g)$$

6. If the temperature change of the water in the calorimeter is +55.5 °C, then the experimental molar enthalpy of combustion for sucrose is approximately

A. -8.72×10^{-1} kJ/mol

B. -1.40×10^{1} kJ/mol

C. -5.81×10^{1} kJ/mol

D. -3.88×10^{3} kJ/mol

7. *If included as a term in the equation above, energy is a* ___***i***___ *, and the water in the calorimeter undergoes a change primarily in* ___***ii***___ *energy.*

The statement above is completed by the information in row

Row	***i***	***ii***
A.	reactant	kinetic
B.	reactant	potential
C.	product	kinetic
D.	product	potential

Use the following information to answer the next question.

$$2\,KClO_3(s) \rightarrow 2\,KCl(s) + 3\,O_2(g) \qquad \Delta H^\circ = ?$$

Numerical Response

3. The enthalpy change for the reaction represented by the equation above is +/–_____ kJ.

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

Use the following information to answer the next question.

Hydrogen peroxide solutions are available commercially because hydrogen peroxide decomposes very slowly. When $MnO_2(s)$ is added to a solution of hydrogen peroxide, the hydrogen peroxide decomposes rapidly, as represented by the following equation.

$$2\,H_2O_2(aq) \xrightarrow{MnO_2(s)} 2\,H_2O(l) + O_2(g) + \text{energy}$$

8. In the reaction represented by the equation above, $MnO_2(s)$ acts to

A. increase the activation energy

B. increase the energy released by the reaction

C. reduce the net energy released by the reaction

D. provide an alternative energy pathway for the reaction

Use the following information to answer the next two questions.

Some foods are available in insulated packages containing chemicals that produce an exothermic reaction that heats the food. When excess water and powdered magnesium metal react in the presence of an iron catalyst, energy is released. The reaction is represented by the following equation.

Reaction Used to Heat Packaged Food

$$Mg(s) + 2\,H_2O(l) \rightarrow Mg(OH)_2(s) + H_2(g)$$

9. *In the reaction used to heat packaged food, the oxidizing agent is* ___***i***___ *, and the amount of electrons transferred when 1 mol of powdered magnesium metal reacts is* ___***ii***___ .

The statement above is completed by the information in row

Row	*i*	*ii*
A.	Mg(s)	1 mol
B.	Mg(s)	2 mol
C.	$H_2O(l)$	1 mol
D.	$H_2O(l)$	2 mol

Use the following additional information to answer the next question.

Statements About the Heating Reaction

1 The rate of reaction increases.

2 The $\Delta H°$ value for the reaction increases.

3 The $\Delta H°$ value for the reaction stays the same.

4 The potential energy of the products increases.

10. Which of the statements numbered above describes the effect of the iron catalyst on the reaction used to heat packaged food?

A. 1 only

B. 1 and 3

C. 1, 2, and 4

D. 2 and 4 only

Use the following information to answer the next two questions.

Nitrogen monoxide gas, which is used to treat some pulmonary diseases, is transported in pressurized gas cylinders. Nitrogen monoxide gas is produced by reacting ammonia gas and oxygen gas, as represented by the following equation.

Equation I $4\,NH_3(g) + 5\,O_2(g) \rightarrow 4\,NO(g) + 6\,H_2O(g)$

Under high pressure in the gas cylinder, nitrogen monoxide gas can undergo the reaction represented by the following equation.

Equation II $3\,NO(g) \rightarrow N_2O(g) + NO_2(g)$

Numerical Response

4. The oxidation number for nitrogen in

$NH_3(g)$ is +/–_____ (Record in the **first** column)

$NO(g)$ is +/–_____ (Record in the **second** column)

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

$NO_2(g)$ is +/–_____ (Record in the **fourth** column)

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

11. *During the reaction represented by equation II, nitrogen monoxide undergoes* ___***i***___ *and* ___***ii***___ *electrons.*

The statement above is completed by the information in row

Row	*i*	*ii*
A.	disproportionation	oxygen gains and loses
B.	disproportionation	nitrogen gains and loses
C.	oxidation	oxygen loses
D.	oxidation	nitrogen loses

Use the following information to answer the next question.

Under acidic conditions, certain organisms carry out anaerobic respiration by using oxidizing agents other than oxygen. A half-reaction involved in anaerobic respiration is represented by the following **unbalanced** equation.

$$\_\_SO_4^{2-}(aq) + \_\_H^+(aq) + \_\_e^- \rightarrow \_\_HS^-(aq) + \_\_H_2O(l)$$

Numerical Response

5. When the equation above is balanced using lowest whole-number coefficients, the coefficient of

$SO_4^{2-}(aq)$ is _____ (Record in the **first** column)

$H^+(aq)$ is _____ (Record in the **second** column)

e^- is _____ (Record in the **third** column)

$H_2O(l)$ 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.

Reduction and Oxidation Statements

I Solid magnesium reacts to form Mg^{2+} ions.

II Tin metal forms stable ions by losing electrons.

III Oxygen gas forms stable ions by gaining electrons.

IV Zinc metal is extracted from ore containing ZnS(s).

V The oxidation number of sulfur changes from +2 to −2.

VI The oxidation number of sulfur changes from +4 to +6.

12. The statements numbered above that describe oxidation are

A. I, II, and VI

B. I, IV, and VI

C. II, IV, and V

D. III, IV, and V

Use the following information to answer the next question.

Reduction Half-Reactions

$Am^{4+}(aq) + e^- \rightarrow Am^{3+}(aq)$	$E° = +4.60$ V
$Tl^{3+}(aq) + 2\,e^- \rightarrow Tl^{+}(aq)$	$E° = +1.25$ V
$Ac^{3+}(aq) + 3\,e^- \rightarrow Ac(s)$	$E° = -2.20$ V
$Cs^{+}(aq) + e^- \rightarrow Cs(s)$	$E° = -3.03$ V

13. Which of the following equations represents a spontaneous oxidation–reduction reaction?

A. $Ac(s) + 3\,Cs^{+}(aq) \rightarrow 3\,Cs(s) + Ac^{3+}(aq)$

B. $Cs(s) + Am^{4+}(aq) \rightarrow Am^{3+}(aq) + Cs^{+}(aq)$

C. $2\,Ac^{3+}(aq) + 3\,Tl^{+}(aq) \rightarrow 3\,Tl^{3+}(aq) + 2\,Ac(s)$

D. $Tl^{3+}(aq) + 2\,Am^{3+}(aq) \rightarrow 2\,Am^{4+}(aq) + Tl^{+}(aq)$

Use the following information to answer the next question.

Spontaneous Redox Reactions

$$Co^{3+}(aq) + Ce^{3+}(aq) \xrightarrow{\text{spontaneous}} Co^{2+}(aq) + Ce^{4+}(aq)$$

$$2\,Hg^{+}(aq) + Be(s) \xrightarrow{\text{spontaneous}} 2\,Hg(l) + Be^{2+}(aq)$$

$$Ce^{4+}(aq) + Hg(l) \xrightarrow{\text{spontaneous}} Ce^{3+}(aq) + Hg^{+}(aq)$$

14. The strongest oxidizing agent in the equations above is

A. $Co^{3+}(aq)$

B. $Ce^{3+}(aq)$

C. $Hg^{+}(aq)$

D. $Ce^{4+}(aq)$

15. A 1.0 mol/L solution of $Ni(NO_3)_2(aq)$ could be stored in a container made of

A. tin

B. iron

C. zinc

D. chromium

Use the following information to answer the next question.

Ethene is produced from ethane found in natural gas. The ethene is transported through iron pipelines to chemical plants in order to be converted into other products, such as ethylene glycol and polyethylene. The buried iron pipeline is subject to corrosion, due in part to trapped air in damp soil.

16. Which of the following actions could prevent the corrosion of the pipeline?

A. Using a pipeline made of copper

B. Using a pipeline made of chromium

C. Connecting strips of lead to the pipeline at appropriate intervals

D. Connecting strips of zinc to the pipeline at appropriate intervals

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Use the following information to answer the next question.

A 15.0 mL sample of $Na_2S_2O_3(aq)$ is titrated to a pink endpoint with 25.0 mL of 12.3 mmol/L acidified $KMnO_4(aq)$. This titration reaction is represented by the equation

$$5\ S_2O_3^{2-}(aq) + 8\ MnO_4^{-}(aq) + 14\ H^{+}(aq) \rightarrow 10\ SO_4^{2-}(aq) + 8\ Mn^{2+}(aq) + 7\ H_2O(l)$$

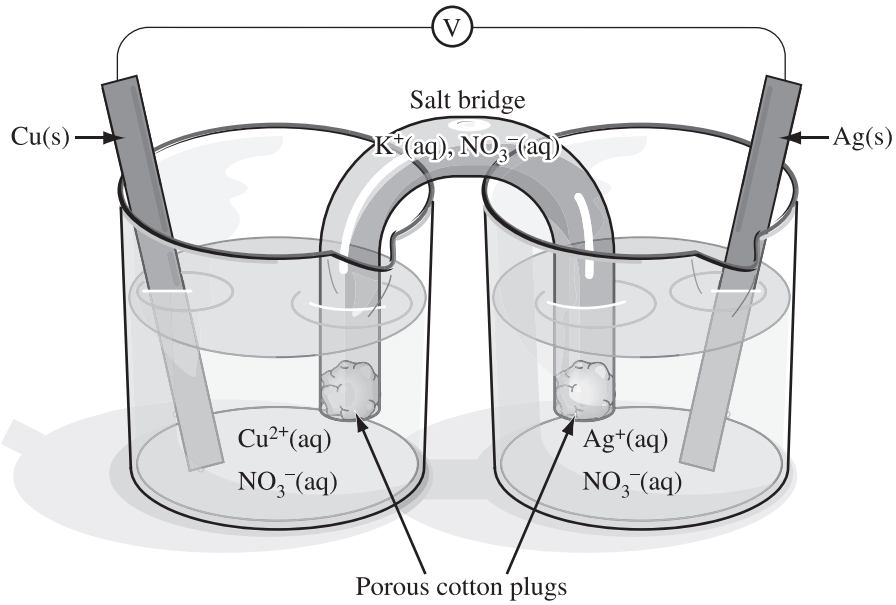
Numerical Response

6. The concentration of the $Na_2S_2O_3(aq)$ solution is _____ mmol/L.

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

Use the following information to answer the next question.

A Standard Copper–Silver Cell



Descriptions of Electrochemical Cells

1 This is a voltaic cell.

2 This is an electrolytic cell.

3 The mass of Cu(s) increases.

4 The mass of Ag(s) increases.

5 A spontaneous reaction occurs.

6 A nonspontaneous reaction occurs.

7 Anions flow toward the Cu(s) electrode.

8 Anions flow toward the Ag(s) electrode.

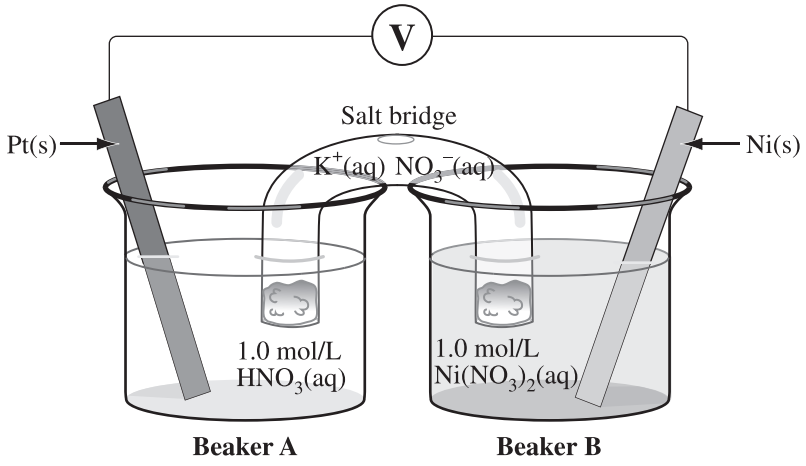
Numerical Response

7. The electrochemical cell descriptions that apply to this operating, standard copper–silver cell 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.

Electrochemical Cell



Numerical Response

8. If the standard silver reduction half-reaction had been chosen as the reference half-reaction instead of the hydrogen reduction half-reaction, then the electrical potential of the cell represented by the diagram above would 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.

One type of bleach is manufactured by adding chlorine gas to a sodium hydroxide solution, as represented by the equilibrium equation below.

$$Cl_2(g) + 2\,OH^-(aq) \rightleftharpoons OCl^-(aq) + Cl^-(aq) + H_2O(l)$$

If the pH of this equilibrium system is maintained at approximately 8, then $OCl^-(aq)$ and $Cl^-(aq)$ are the predominant chlorine-containing species in the solution.

17. The E°_{net} for the forward reaction is

A. +2.20 V

B. +1.36 V

C. +0.55 V

D. +0.52 V

Use the following information to answer the next question.

Statements About Electrochemical Cells

1 The net potential is positive.

2 The net potential is negative.

3 Reduction occurs at the cathode.

4 Cations travel toward the cathode.

5 Electrons travel toward the cathode.

6 A flow of electrons is spontaneously generated.

7 The strongest oxidizing agent reacts at the cathode.

Numerical Response

9. The statements above that apply to both a voltaic cell and an electrolytic cell 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.

A student sets up a standard copper–zinc voltaic cell in a laboratory and measures the net potential.

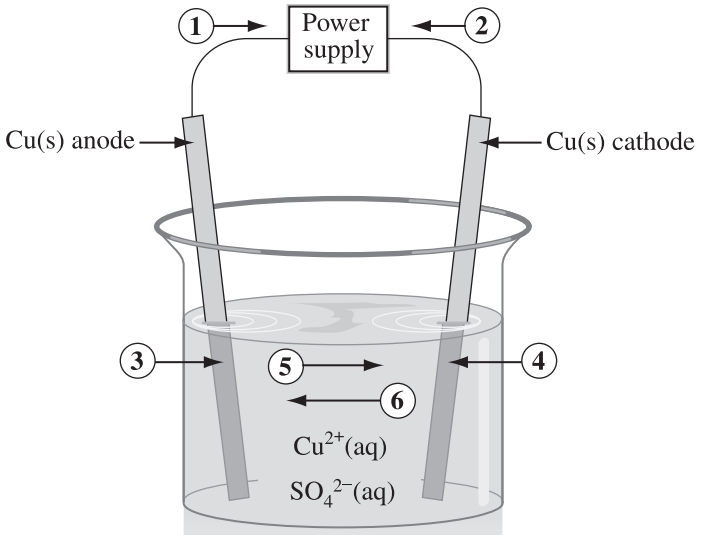
18. *Compared with solid zinc, solid copper is a* ___***i***___ *reducing agent, and during the operation of this cell, the zinc electrode* ___***ii***___ *electrons.*

The statement above is completed by the information in row

Row	***i***	***ii***
A.	weaker	gains
B.	weaker	loses
C.	stronger	gains
D.	stronger	loses

Use the following information to answer the next two questions.

Electrochemical Cell



19. If a current of 0.850 A is applied to the electrochemical cell above for 60.0 min, then the mass of copper produced is

A. 0.016 8 g

B. 1.01 g

C. 2.02 g

D. 4.03 g

Numerical Response

10. Match the numbers on the electrochemical cell above with the descriptors below.

Increases in mass _____ (Record in the **first** column)

Movement of cations _____ (Record in the **second** column)

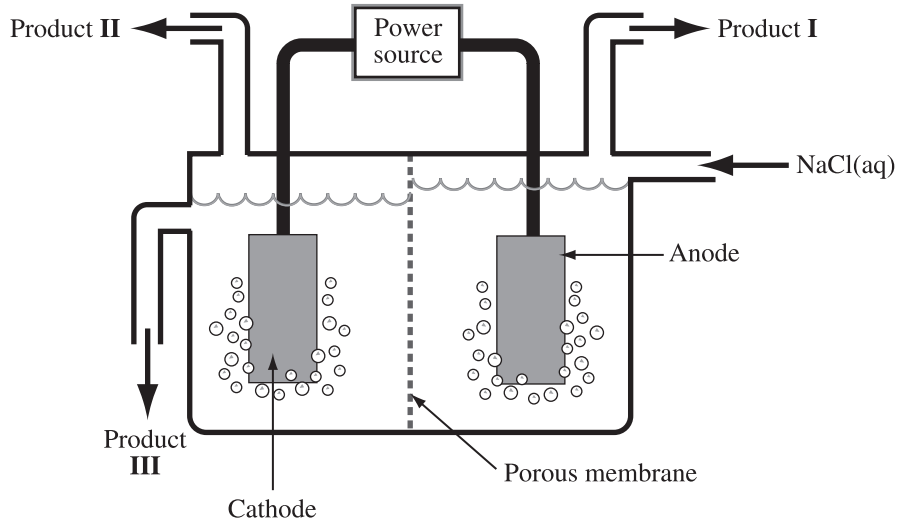
Movement of electrons _____ (Record in the **third** column)

Site where oxidation occurs _____ (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.

Sodium hydroxide can be prepared by the electrolysis of aqueous sodium chloride, as represented by the diagram below.



20. During the electrolysis of a sodium chloride solution, the reduction reaction is

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

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

C. $Cl_2(g) + 2\,e^- \rightleftharpoons 2\,Cl^-(aq)$

D. $2\,Cl^-(aq) \rightleftharpoons Cl_2(g) + 2\,e^-$

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21. The molecular formula for 2,5-dimethylcyclohexan-1-ol is

A. C_6H_6O

B. $C_6H_{12}O$

C. $C_8H_{13}O$

D. $C_8H_{16}O$

Use the following information to answer the next two questions.

Organic Acids

1	Butanoic acid	$C_3H_7COOH(l)$
2	Methanoic acid	$HCOOH(l)$
3	Octanoic acid	$C_7H_{15}COOH(l)$
4	Octadecanoic acid	$CH_3(CH_2)_{16}COOH(l)$

22. *Butanoic acid can be described as an* ___***i***___ *compound, and the functional group in butanoic acid is* ___***ii***___ .

The statement above is completed by the information in row

Row	*i*	*ii*
A.	aromatic	a carboxyl
B.	aromatic	an ester
C.	aliphatic	a carboxyl
D.	aliphatic	an ester

Numerical Response

11. Listed in order from the acid that has the **lowest** boiling point to the acid that has the **highest** boiling point, the four organic acids above are numbered

_____ , _____ , _____ , and _____ .
Lowest boiling point **Highest boiling point**

(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.

Molecules

1 pent-2-ene
2 pent-2-yne
3 cyclopentane
4 methylpropane
5 dimethylpropane
6 ethylcyclopropane
7 methylcyclobutane

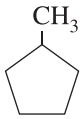
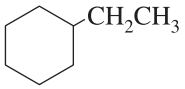
Numerical Response

12. The four molecules listed above that are isomers of $C_5H_{10}(l)$ 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.

Structures and Descriptions

1		**4**	Branched	**7**	Unsaturated
2		**5**	Unbranched	**8**	Alkane
3		**6**	Saturated	**9**	Alkene

Numerical Response

13. The structures and descriptions above that apply to methylcyclopentane are numbered _____, _____, _____, and _____.

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

23. *A mixture of liquid methanol and liquid ethanol can be separated by* ***i*** *, and the physical characteristic of these compounds that allows the separation is* ***ii*** *.*

The statement above is completed by the information in row

Row	*i*	*ii*
A.	fractional distillation	solubility
B.	fractional distillation	boiling point
C.	precipitation	solubility
D.	precipitation	boiling point

Use the following information to answer the next question.

$$C_2H_4(g) + Br_2(l) \rightarrow \textbf{?}$$

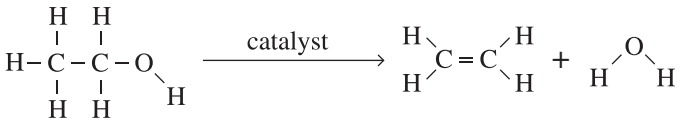
24. *The reactants above undergo an* ___***i***___ *reaction, and the product of the reaction is 1,2-dibromo*___***ii***___ .

The statement above is completed by the information in row

Row	*i*	*ii*
A.	elimination	ethane
B.	elimination	ethene
C.	addition	ethane
D.	addition	ethene

Use the following information to answer the next question.

Ethene is a plant hormone that causes fruits and vegetables to ripen. Ethene can be produced artificially by the reaction represented by the following equation.



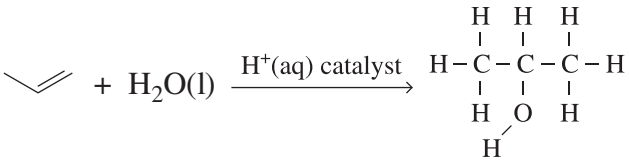
25. *Ethene can be described as both an* ___***i***___ *compound and* ___***ii***___ *molecule.*

The statement above is completed by the information in row

Row	*i*	*ii*
A.	aliphatic	a saturated
B.	aliphatic	an unsaturated
C.	aromatic	a saturated
D.	aromatic	an unsaturated

Use the following information to answer the next question.

Propan-2-ol can be produced from propene and water, as represented by the following equation.



26. *The production of propan-2-ol from propene is* ___***i***___ *reaction. Propan-2-ol is likely to be* ___***ii***___ *in water.*

The statement above is completed by the information in row

Row	*i*	*ii*
A.	a substitution	soluble
B.	a substitution	insoluble
C.	an addition	soluble
D.	an addition	insoluble

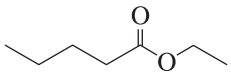
---

27. Which of the following rows identifies a reactant and its product in a polymerization reaction?

Row	Reactant	Product
A.	Ethene	Ethene
B.	Ethene	Polyethene
C.	Propene	Ethene
D.	Propene	Polyethene

Use the following information to answer the next question.

Esters with pleasant odours and flavours are often used as food additives. An ester that is used for its fruity apple flavour is shown below.



28. *The ester shown above could be produced by the reaction of* ___***i***___ *and* ___***ii***___ .

The statement above is completed by the information in row

Row	***i***	***ii***
A.	ethanoic acid	pentan-1-ol
B.	ethanoic acid	butan-1-ol
C.	pentanoic acid	propan-1-ol
D.	pentanoic acid	ethanol

Use the following information to answer the next three questions.

A technician places a sample of sulfur trioxide gas and a sample of carbon dioxide gas in an empty 1.0 L flask and allows them to reach equilibrium at 800 °C. The equilibrium system that is established in the flask is represented by the following equation.

$$\mathbf{2}\,SO_3(g) + CO_2(g) \rightleftharpoons CS_2(g) + \mathbf{4}\,O_2(g) \qquad \Delta H = +1\,301.6\ kJ$$

Changes to the Equilibrium System

I The addition of a catalyst

II A decrease in the volume of the container

III An increase in the temperature of the system

29. In the reaction represented by the equation above, the molar enthalpy of formation of $CS_2(g)$ is

A. +116.7 kJ/mol

B. +512.4 kJ/mol

C. +1 699.5 kJ/mol

D. +2 486.5 kJ/mol

Numerical Response

14. If at equilibrium the concentration of $SO_3(g)$ is 0.289 mol/L; the concentration of $CO_2(g)$ is 0.018 0 mol/L; the concentration of $CS_2(g)$ is 0.201 mol/L; and the concentration of $O_2(g)$ is 0.900 mol/L, then the K_c value for the system at 800 °C is _____.

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

30. Which of the changes to the equilibrium system numbered above would affect the value of the equilibrium constant?

A. I and III only

B. I, II, and III

C. II only

D. III only

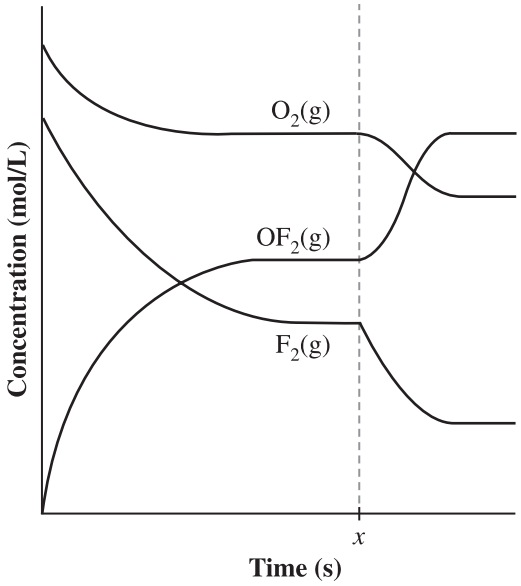
Use the following information to answer the next question.

A technician injected fluorine gas and oxygen gas into an empty 1.0 L reaction vessel. She closed the vessel and allowed the reaction to reach equilibrium, as represented by the following equation.

$$2F_2(g) + O_2(g) + 46.0\ kJ \rightleftharpoons 2OF_2(g)$$

The technician changed the reaction conditions and allowed a new equilibrium to be established as represented by the graph below.

Changes to the Equilibrium System



31. Which of the following stresses represents the change in the equilibrium system at time x on the graph above?

A. A catalyst is added.

B. Pressure is decreased.

C. Temperature is increased.

D. Fluorine gas is removed from the vessel.

Use the following information to answer the next question.

Equilibrium System

$$H_2(g) + Cl_2(g) \rightleftharpoons 2\,HCl(g) + 184.65\ kJ$$

Stresses

I The addition of $H_2(g)$

II The addition of HCl(g)

III The cooling of the equilibrium system

IV An increase in the volume of the container

32. The stresses numbered above that would cause the equilibrium system to shift toward the products are

A. I and III only

B. I, III, and IV

C. II and III only

D. II, III, and IV

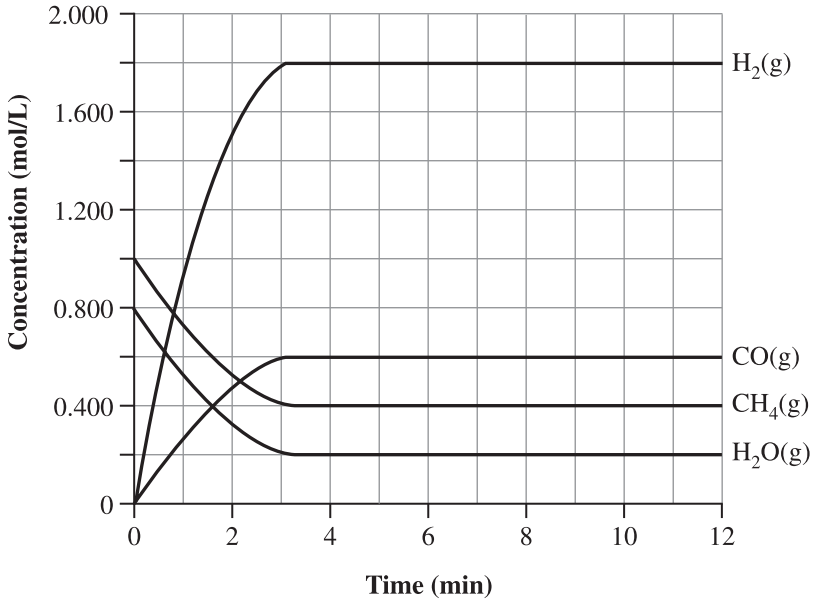
Use the following information to answer the next question.

A technician is producing hydrogen gas. He adds methane gas, steam, and a nickel catalyst to an empty reaction container and allows the system to reach equilibrium. The reaction is represented by the following equation.

$$CH_4(g) + H_2O(g) \rightleftharpoons 3\,H_2(g) + CO(g)$$

The technician's data are represented by the following graph.

Production of Hydrogen at 500 °C



Numerical Response

15. The equilibrium constant for the reaction represented in the graph above is _____.

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

Use the following information to answer the next question.

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

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

33. *If during the titration the pH of the solution changes from 9.2 to 7.2, then the acidity of the solution* ___***i***___ *and the hydronium ion concentration* ___***ii***___ *by a factor of 100.*

The statement above is completed by the information in row

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

Use the following information to answer the next question.

A sample of hydrogen iodide gas, HI(g), is collected and then dissolved in 10.0 L of water.

Statements About Solutions

1 The pH is less than the pOH.

2 The pH is greater than the pOH.

3 The solution conducts electricity.

4 The solution does not conduct electricity.

5 Almost all of the HI(aq) ionizes in the solution.

6 Most of the HI(aq) does not ionize in the solution.

7 The concentration of $H_3O^+(aq)$ is less than the concentration of $OH^-(aq)$.

8 The concentration of $H_3O^+(aq)$ is greater than the concentration of $OH^-(aq)$.

Numerical Response

16. The statements above that describe the hydrogen iodide solution 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 following equilibrium system maintains a constant pH in the intracellular fluid in the body.

$$H_2PO_4^-(aq) + H_2O(l) \rightleftharpoons HPO_4^{2-}(aq) + H_3O^+(aq)$$

34. *A Brønsted–Lowry acid in the equilibrium system represented by the equation above is* ___***i***___ *, and it will* ___***ii***___ *the Brønsted–Lowry base.*

The statement above is completed by the information in row

Row	*i*	*ii*
A.	$H_2O(l)$	donate protons to
B.	$H_2O(l)$	accept protons from
C.	$H_2PO_4^-(aq)$	donate protons to
D.	$H_2PO_4^-(aq)$	accept protons from

Use the following additional information to answer the next question.

Terms Associated with Acid–Base Equilibrium Systems

1 Buffer
2 Amphiprotic
3 Polyprotic acid
4 Polyprotic base
5 Conjugate acid–base pair

35. Which of the terms numbered above can be used to describe the reaction or the species in the reaction in the equilibrium system above?

A. 1 and 5 only
B. 2 and 3 only
C. 2, 4, and 5 only
D. 1, 2, 3, 4, and 5

Use the following information to answer the next question.

A solution containing the ammonium ion, $NH_4^+(aq)$, is mixed with a solution containing the hydrogen carbonate ion, $HCO_3^-(aq)$.

36. *In the forward reaction, 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.	$HCO_3^-(aq)$	$H_2CO_3(aq)$
B.	$HCO_3^-(aq)$	$NH_4^+(aq)$
C.	$NH_4^+(aq)$	$HCO_3^-(aq)$
D.	$NH_4^+(aq)$	$NH_3(aq)$

Use the following information to answer the next question.

$$C_2H_5OCOOH(aq) + NO_2^-(aq) \rightleftharpoons HNO_2(aq) + C_2H_5OCOO^-(aq)$$

37. Which of the following rows identifies the stronger acid and the side of the equilibrium that is favoured?

Row	Stronger Acid	Side Favoured
A.	$HNO_2(aq)$	products
B.	$HNO_2(aq)$	reactants
C.	$C_2H_5OCOOH(aq)$	products
D.	$C_2H_5OCOOH(aq)$	reactants

Use the following information to answer the next question.

Monoprotic Organic Acids			
Acid Name	**Acid Formula**	**Conjugate Base Formula**	K_a
Chloroacetic acid	$C_2H_3ClO_2(aq)$	$C_2H_2ClO_2^-(aq)$	1.3×10^{-3}
Salicylic acid	$C_7H_6O_3(aq)$	$C_7H_5O_3^-(aq)$	1.0×10^{-3}
Glycolic acid	$C_2H_4O_3(aq)$	$C_2H_3O_3^-(aq)$	1.5×10^{-4}
Lactic acid	$C_3H_6O_3(aq)$	$C_3H_5O_3^-(aq)$	1.4×10^{-4}

38. The Brønsted–Lowry equation that represents a reaction that favours the products is

A. $C_3H_6O_3(aq) + C_2H_3O_3^-(aq) \rightleftharpoons C_3H_5O_3^-(aq) + C_2H_4O_3(aq)$

B. $C_7H_6O_3(aq) + C_3H_5O_3^-(aq) \rightleftharpoons C_7H_5O_3^-(aq) + C_3H_6O_3(aq)$

C. $C_7H_6O_3(aq) + C_2H_2ClO_2^-(aq) \rightleftharpoons C_7H_5O_3^-(aq) + C_2H_3ClO_2(aq)$

D. $C_2H_4O_3(aq) + C_2H_2ClO_2^-(aq) \rightleftharpoons C_2H_3O_3^-(aq) + C_2H_3ClO_2(aq)$

Use the following information to answer the next two questions.

Selected Acids and Bases

I	$H_2O(l)$
II	$OH^-(aq)$
III	$OCl^-(aq)$
IV	$HC_6H_6O_6^-(aq)$
V	$HOOCCOO^-(aq)$
VI	$HOOCCOOH(aq)$

39. The amphiprotic species listed above are

A. I, II, and V

B. I, III, and VI

C. I, IV, and V

D. I, V, and VI

40. The two species listed above that could be combined to prepare a buffer solution are

A. I and III

B. III and IV

C. III and VI

D. V and VI

Use the following information to answer the next question.

Sodium fluoroethanoate, $NaCH_2FCOO(aq)$, is a potent metabolic poison that can be used to kill rodents. The conjugate acid of the fluoroethanoate ion is fluoroethanoic acid, CH_2FCOOH. For this acid, $K_a = 2.6 \times 10^{-3}$.

41. *The value of K_b of $CH_2FCOO^-(aq)$ is* ___***i***___ *, and $CH_2FCOO^-(aq)$ is a stronger base than* ___***ii***___ .

The statement above is completed by the information in row

Row	***i***	***ii***
A.	3.8×10^{-12}	$H_2PO_4^-(aq)$
B.	3.8×10^{-12}	$PO_4^{3-}(aq)$
C.	2.6×10^{-3}	$H_2PO_4^-(aq)$
D.	2.6×10^{-3}	$PO_4^{3-}(aq)$

42. A brand of window-cleaning fluid is composed of an ammonia solution, water, a colouring agent, and a very small quantity of soap. It has a 0.15 mol/L concentration of $NH_3(aq)$. The pH of this fluid is

A. 2.79

B. 5.04

C. 8.96

D. 11.21

43. The concentration of $H_3O^+(aq)$ in a 0.040 mol/L $H_2S(aq)$ solution is

A. 3.0×10^{-4} mol/L

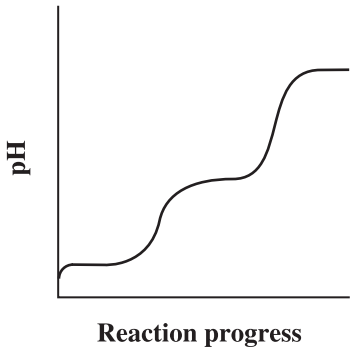
B. 6.0×10^{-5} mol/L

C. 2.2×10^{-6} mol/L

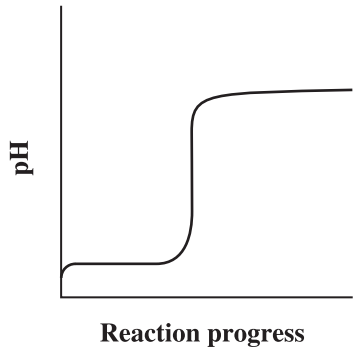
D. 3.6×10^{-9} mol/L

44. Which of the following pH curves represents the titration of an acid with a strong base, if one intermediate amphiprotic substance is produced?

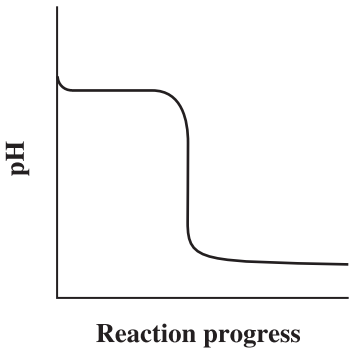
A.



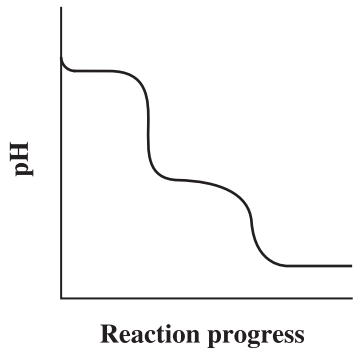
B.



C.



D.



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

Key: MC–Multiple Choice; NR–Numerical Response

Question	Key	*Diff. %	Question	Key	*Diff. %
MC1	A	78.6	**MC23**	B	77.4
MC2	C	69.8	**MC24**	C	73.1
MC3	C	70.3	**NR9**	3457 (any order)	52.7
MC4	A	41.9	**NR10**	4513	53.5
NR1	2467 (any order)	72.1	**MC25**	B	72.4
NR2	4.52	32.2	**MC26**	C	58.6
MC5	D	79.4	**MC27**	B	79.4
MC6	D	67.1	**MC28**	D	61.5
MC7	C	59.0	**NR11**	2134	76.4
MC8	D	59.5	**MC29**	A	44.2
NR3	77.6	59.1	**MC30**	D	64.1
MC9	D	58.5	**MC31**	C	58.3
MC10	B	69.3	**MC32**	A	69.1
NR4	3214	72.6	**MC33**	C	70.9
MC11	B	70.3	**NR12**	1367 (any order)	50.0
MC12	A	76.2	**MC34**	C	77.2
MC13	B	66.4	**MC35**	D	52.0
MC14	A	68.4	**MC36**	A	73.8
MC15	A	70.3	**MC37**	B	50.2
MC16	D	52.7	**MC38**	B	55.5
MC17	D	47.3	**MC39**	C	62.5
MC18	B	62.1	**NR13**	2468 (any order)	66.9
NR5	1984	39.4	**MC40**	D	57.6
MC19	B	42.0	**NR14**	87.7	53.7
MC20	A	30.4	**MC41**	A	61.6
MC21	D	64.6	**NR15**	43.7	48.3
NR6	12.8	46.2	**MC42**	D	36.4
NR7	1457 (any order)	46.7	**NR16**	1358 (any order)	42.2
NR8	1.06	32.6	**MC43**	B	49.5
MC22	C	67.1	**MC44**	A	43.2

*Difficulty–percentage of students answering the question correctly