Use the following information to answer the next two questions.

Some matches consist of a wooden stick and a head that contains tetraphosphorous trisulfide, $P_4S_3(s)$, and that can be ignited on any rough surface. When the match is drawn across a rough surface, enough heat is generated to start the reaction represented by the following equation.

$$P_4S_3(s) + 8\,O_2(g) \rightarrow P_4O_{10}(s) + 3\,SO_2(g)$$

$$\Delta_f H^\circ_{P_4S_3(s)} = -155.0 \text{ kJ/mol}$$

$$\Delta_f H^\circ_{P_4O_{10}(s)} = -2\,984.0 \text{ kJ/mol}$$

1. The energy released during the combustion of the wood in the match originally came from the

A. sun

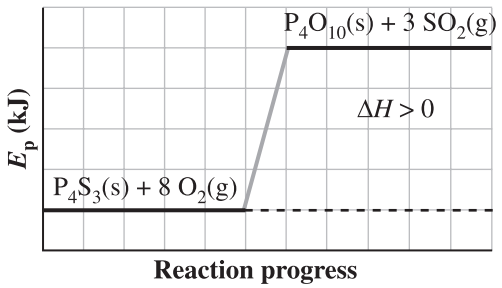
B. atmosphere

C. formation of cellulose in the wood

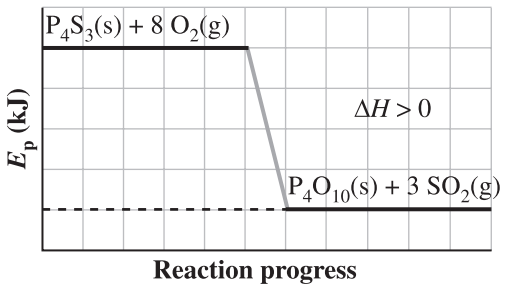
D. decomposition of carbon dioxide and water

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

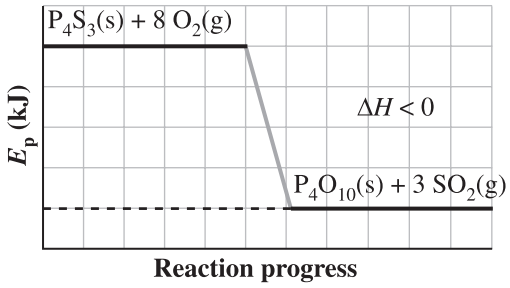
A.



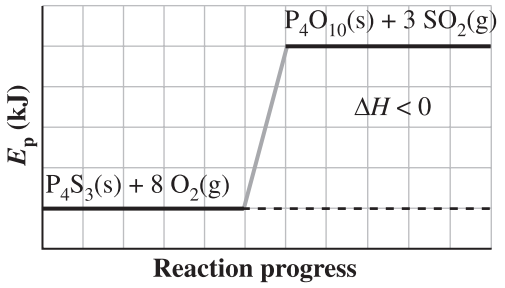
B.



C.



D.



Use the following information to answer the next two questions.

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

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

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

A. $6\,CO_2(g) + 6\,H_2O(l) \rightarrow C_6H_{12}O_6(s) + 6\,O_2(g) + 2\,538.5\ kJ$

B. $6\,CO_2(g) + 6\,H_2O(l) + 2\,538.5\ kJ \rightarrow C_6H_{12}O_6(s) + 6\,O_2(g)$

C. $6\,CO_2(g) + 6\,H_2O(l) \rightarrow C_6H_{12}O_6(s) + 6\,O_2(g) + 2\,802.5\ kJ$

D. $6\,CO_2(g) + 6\,H_2O(l) + 2\,802.5\ kJ \rightarrow C_6H_{12}O_6(s) + 6\,O_2(g)$

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

A. greater than it is during cellular respiration because the production of $H_2O(g)$ releases more energy than does the production of $H_2O(l)$

B. less than it is during cellular respiration because the production of $H_2O(g)$ releases less energy than does the production of $H_2O(l)$

C. the same as it is in cellular respiration because they are identical processes

D. the same as it is in the plant because the enthalpy change is independent of the state of the products

Use the following information to answer the next two questions.

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

$$8\,H_2S(g) + 4\,O_2(g) \rightarrow S_8(s) + 8\,H_2O(g) \qquad \Delta H^\circ = -1\,769.6\ kJ$$

Numerical Response

2. The enthalpy change for 1.00 mol of $H_2S(g)$ during the Claus process, expressed in scientific notation, is $\pm \boldsymbol{a.bc} \times 10^{\boldsymbol{d}}$ kJ/mol. The values of ***a***, ***b***, ***c***, and ***d*** are _____, _____, _____, and _____.

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

5. *During the Claus process, energy is* ___***i***___ *the surroundings, and energy is included as a* ___***ii***___ *in the balanced equation.*

The statement above is completed by the information in row

Row	*i*	*ii*
A.	absorbed from	reactant
B.	absorbed from	product
C.	released to	reactant
D.	released to	product

Use the following information to answer the next question.

A student experimentally determined the molar enthalpy of formation for carbon dioxide gas by burning 1.04 g of C(s) in a calorimeter. The student found that burning the carbon released enough heat to increase the temperature of 1.00 kg of water from 12.00 °C to 19.36 °C.

6. In this experiment, the student determined that the molar enthalpy of formation for carbon dioxide was

A. -1.30×10^3 kJ/mol

B. -3.56×10^2 kJ/mol

C. −30.8 kJ/mol

D. −2.67 kJ/mol

---

7. As dry air is heated from 15.0 °C to 25.0 °C by the combustion of methane in a furnace, the air would primarily undergo

A. a decrease in kinetic energy

B. an increase in kinetic energy

C. a decrease in potential energy

D. an increase in potential energy

Use the following information to answer the next question.

Equations

I	$C_2H_5OH(l) + 3\,O_2(g) \rightarrow 2\,CO_2(g) + 3\,H_2O(l)$	$\Delta H° = -1\,366.8$ kJ
II	$2\,C_2H_4O(l) + 5\,O_2(g) \rightarrow 4\,CO_2(g) + 4\,H_2O(g)$	$\Delta H° = -2\,156.8$ kJ
III	$H_2O(l) \rightarrow H_2O(g)$	$\Delta H° = +44.0$ kJ

8. According to the equations above, the enthalpy change for $2\,C_2H_5OH(l) + O_2(g) \rightarrow 2\,C_2H_4O(l) + 2\,H_2O(l)$ is

A. +834.0 kJ

B. +752.8 kJ

C. −400.8 kJ

D. −532.8 kJ

Use the following information to answer the next question.

Titanium is widely used in the aerospace and sporting goods industries because it is strong, lightweight, and resistant to corrosion. When exposed to oxygen, titanium forms an oxide coating that protects the metal from corrosion. This reaction is represented by the following equation.

$$Ti(s) + O_2(g) \rightarrow TiO_2(s) + 944.0\text{ kJ}$$

9. *The formation of titanium(IV) oxide is* ___***i***___ *, and the reactants have* ___***ii***___ *potential energy than the products.*

The statement above is completed by the information in row

Row	*i*	*ii*
A.	endothermic	higher
B.	endothermic	lower
C.	exothermic	higher
D.	exothermic	lower

Use the following information to answer the next two questions.

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

$$Xe(g) + 2\,F_2(g) \rightarrow XeF_4(s) \qquad \Delta_f H^\circ = -251 \text{ kJ}$$

Numerical Response

3. The energy that is transferred when 69.1 g of $XeF_4(s)$ is produced is _____ kJ.

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

Numerical Response

4. The oxidation number of xenon in

XeF_2 is +/–_____ (Record in the **first** column)

XeF_4 is +/–_____ (Record in the **second** column)

XeF_6 is +/–_____ (Record in the **third** column)

XeO_3 is +/–_____ (Record in the **fourth** column)

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

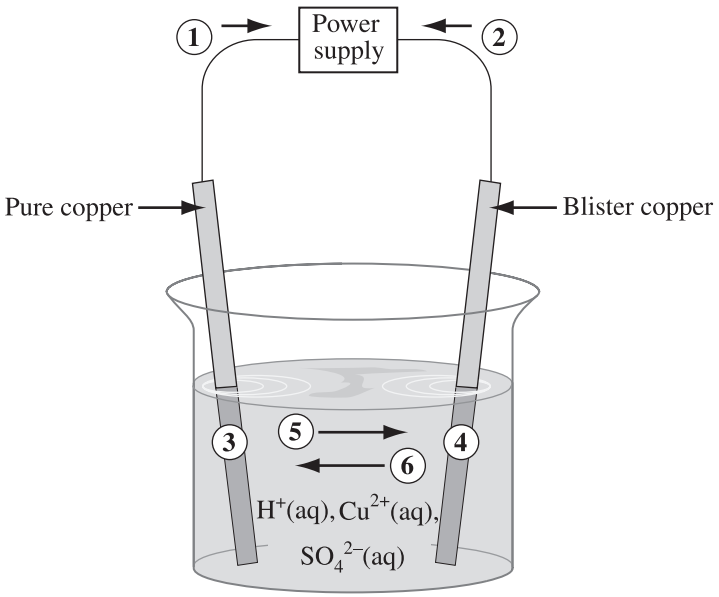
10.

THIS QUESTION WAS DELETED
FROM THE ORIGINAL EXAMINATION.

Use the following information to answer the next two questions.

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

Refining of Copper



11. *The electrochemical cell used in the refining of copper is* ___***i***___ *, and the reaction is* ___***ii***___ *.*

The statement above is completed by the information in row

Row	*i*	*ii*
A.	voltaic	spontaneous
B.	voltaic	nonspontaneous
C.	electrolytic	spontaneous
D.	electrolytic	nonspontaneous

Numerical Response

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

Site where reduction occurs _____ (Record in the **first** column)

Direction of anion movement _____ (Record in the **second** column)

Direction of electron movement _____ (Record in the **third** column)

Electrode that increases in mass _____ (Record in the **fourth** column)

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

Use the following information to answer the next question.

$$3\,I_2(s) + 5\,ClO_3^-(aq) + 3\,H_2O(l) \rightarrow 6\,HIO_3(aq) + 5\,Cl^-(aq)$$

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

A. $I_2(s) + 2\,H^+(aq) + 4\,e^- \rightarrow 2\,I^-(aq) + H_2O(l)$

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

C. $ClO_3^-(aq) + 6\,H^+(aq) + 6\,e^- \rightarrow Cl^-(aq) + 3\,H_2O(l)$

D. $ClO_3^-(aq) + 3\,H_2O(l) + 6\,e^- \rightarrow Cl^-(aq) + 6\,OH^-(aq)$

---

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

A. Copper

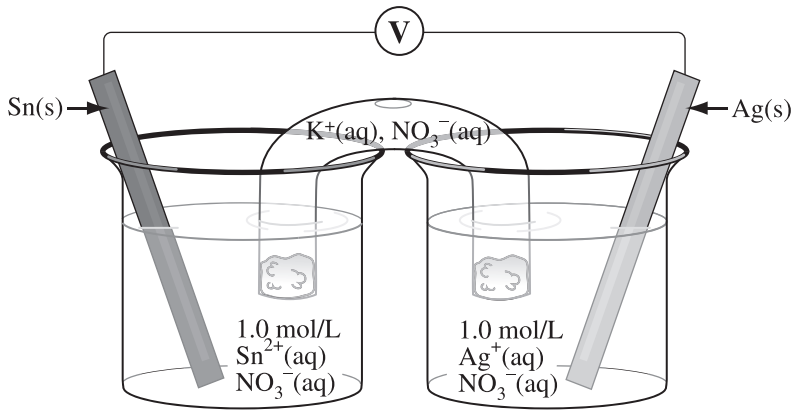
B. Chromium

C. Aluminium

D. Magnesium

Use the following information to answer the next question.

Electrochemical Cell



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

A. $2\,Ag(s) + Sn^{2+}(aq) \rightarrow 2\,Ag^+(aq) + Sn(s)$

B. $2\,Ag(s) + Sn(s) \rightarrow 2\,Ag^+(aq) + Sn^{2+}(aq)$

C. $2\,Ag^+(aq) + Sn^{2+}(aq) \rightarrow 2\,Ag(s) + Sn(s)$

D. $2\,Ag^+(aq) + Sn(s) \rightarrow 2\,Ag(s) + Sn^{2+}(aq)$

Use the following information to answer the next question.

A student is given three metal strips and is asked to identify each strip as silver, lead, or zinc. The student labels the strips X(s), Y(s), and Z(s) and tests each strip in a $Cu(NO_3)_2(aq)$ solution and a $Ni(NO_3)_2(aq)$ solution. The student's observations are shown below.

Evidence of Reaction

	$Cu(NO_3)_2(aq)$	**$Ni(NO_3)_2(aq)$**
X(s)	black precipitate	no reaction
Y(s)	black precipitate	black precipitate
Z(s)	no reaction	no reaction

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

Row	**X(s)**	**Y(s)**	**Z(s)**
A.	silver	lead	zinc
B.	silver	zinc	lead
C.	lead	silver	zinc
D.	lead	zinc	silver

Use the following information to answer the next question.

Equations

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

II $2\,Al(s) + 3\,Cl_2(g) \rightarrow 2\,AlCl_3(s)$

III $CuS(s) + H_2(g) \rightarrow Cu(s) + H_2S(g)$

IV $2\,PbO(s) + C(s) \rightarrow 2\,Pb(s) + CO_2(g)$

V $Fe_2O_3(s) + CO(g) \rightarrow 2\,FeO(s) + CO_2(g)$

16. Which of the equations numbered above represents a reaction in which the metal is oxidized?

A. I and II only

B. I, II, and V

C. I, IV, and V

D. III and IV

17. If the $Ni^{2+}(aq) + 2\,e^- \rightarrow Ni(s)$ half-reaction is designated as the reference half-reaction with an electrode potential of 0.00 V, then the electrical potential for the $Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$ half-reaction is

A. +1.03 V

B. +0.51 V

C. −0.51 V

D. −1.03 V

Use the following information to answer the next question.

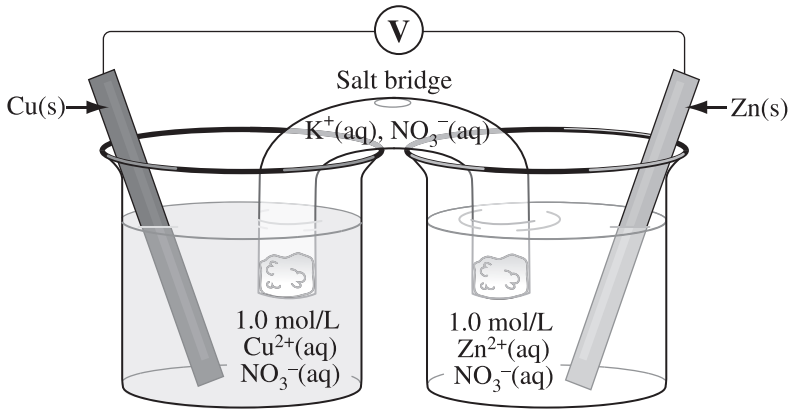
$Ce^{4+}(aq) + Cu^{+}(aq) \rightarrow Ce^{3+}(aq) + Cu^{2+}(aq)$	spontaneous
$Co^{2+}(aq) + Ce^{4+}(aq) \rightarrow Co^{3+}(aq) + Ce^{3+}(aq)$	nonspontaneous
$2\,Cu^{2+}(aq) + Mn(s) \rightarrow 2\,Cu^{+}(aq) + Mn^{2+}(aq)$	spontaneous

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

Row	***Strongest***			***Weakest***
A.	$Cu^{2+}(aq)$	$Mn^{2+}(aq)$	$Co^{3+}(aq)$	$Ce^{4+}(aq)$
B.	$Ce^{4+}(aq)$	$Co^{3+}(aq)$	$Cu^{2+}(aq)$	$Mn^{2+}(aq)$
C.	$Co^{3+}(aq)$	$Ce^{4+}(aq)$	$Cu^{2+}(aq)$	$Mn^{2+}(aq)$
D.	Mn(s)	$Cu^{+}(aq)$	$Ce^{3+}(aq)$	$Co^{2+}(aq)$

Use the following information to answer the next two questions.

Electrochemical Cell



19. The E°_{cell} for the electrochemical cell above is

A. +1.10 V

B. +0.42 V

C. −0.42 V

D. −1.10 V

20. Which of the following statements applies to the operation of the electrochemical cell?

A. A precipitate forms on the Zn(s) electrode.

B. The concentration of $Zn^{2+}(aq)$ ions decreases.

C. Electrons move through the connecting wires toward the Zn(s) electrode.

D. The $NO_3^-(aq)$ ions move through the salt bridge toward the Zn(s) electrode.

Use the following information to answer the next two questions.

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

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

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

Volume of $S_2O_3^{2-}(aq)$ Used During the Titration

Trial	**I**	**II**	**III**
Final burette reading (mL)	7.82	14.41	20.96
Initial burette reading (mL)	1.19	7.82	14.41

21. *In the titration reaction, the reducing agent is* ___***i***___ *and* ___***ii***___ *atoms are reduced.*

The statement above is completed by the information in row

Row	***i***	***ii***
A.	$I_2(aq)$	iodine
B.	$I_2(aq)$	sulfur
C.	$S_2O_3^{2-}(aq)$	iodine
D.	$S_2O_3^{2-}(aq)$	sulfur

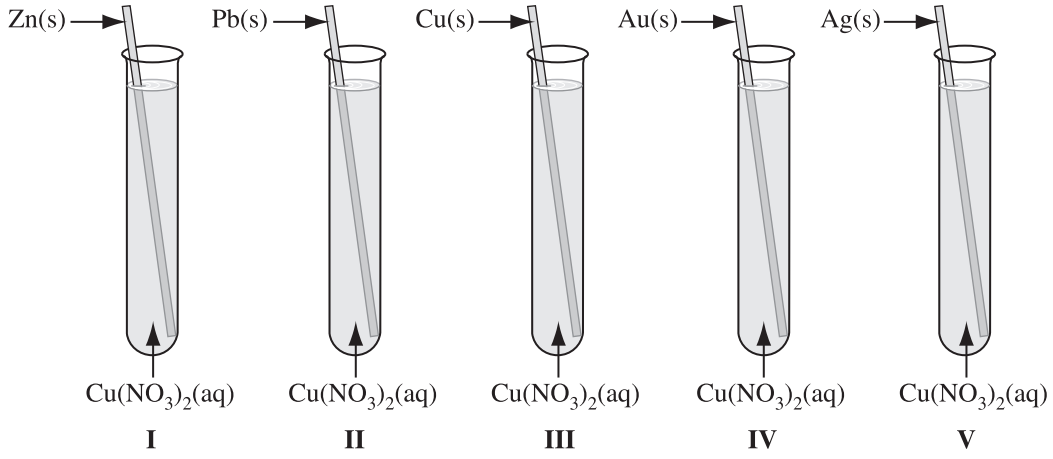
Numerical Response

6. The concentration of $I_2(aq)$, expressed in scientific notation, is $\boldsymbol{a.bc} \times 10^{-\boldsymbol{d}}$ mol/L. The values of ***a***, ***b***, ***c***, and ***d*** are _____, _____, _____, and _____.

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

Use the following information to answer the next question.

In an experiment to study the spontaneity of redox reactions, a student placed a different strip of metal into five separate test tubes, each containing 1.0 mol/L copper(II) nitrate solution, as shown below.



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

A. I and II only

B. I, II, and III

C. I, II, IV, and V

D. IV and V only

Use the following information to answer the next question.

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

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

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

A. $Cl_2(g)$

B. $OH^-(aq)$

C. $OCl^-(aq)$

D. $H_2O(l)$

Use the following information to answer the next question.

$$3\,I_2(s) + 5\,ClO_3^-(aq) + 3\,H_2O(l) \rightarrow 6\,HIO_3(aq) + 5\,Cl^-(aq)$$

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

The statement above is completed by the information in row

Row	*i*	*ii*
A.	$I_2(s)$	30
B.	$I_2(s)$	10
C.	$ClO_3^-(aq)$	30
D.	$ClO_3^-(aq)$	10

Use the following information to answer the next question.

Carbon-Containing Compounds

1	$C_2H_4(g)$	**5**	$CO_2(g)$
2	$CaC_2(s)$	**6**	$HCN(g)$
3	$CH_3Cl(g)$	**7**	$C_8H_{18}(l)$
4	$CH_3OH(l)$	**8**	$CuCO_3(s)$

Numerical Response

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

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

Use the following information to answer the next two questions.

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

25. *When aqueous bromine is added to cycloheptane and cycloheptene, the cycloheptane undergoes* ___***i***___ *reaction, and the cycloheptene undergoes* ___***ii***___ *reaction.*

The statement above is completed by the information in row

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

26. *Cycloheptane is* ___***i***___ *hydrocarbon, and cycloheptene is* ___***ii***___ *hydrocarbon.*

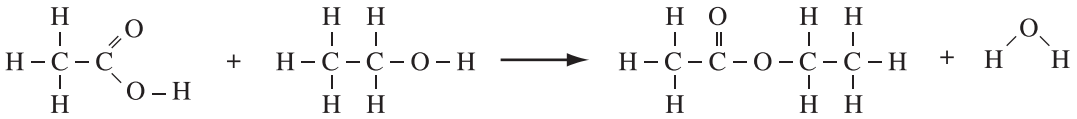
The statement above is completed by the information in row

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

Use the following information to answer the next question.

Reaction Equation

I **II**



Names and Terms

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

Numerical Response

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

Type of reaction _____ (Record in the **first** column)

Name of compound I _____ (Record in the **second** column)

Name of compound II _____ (Record in the **third** column)

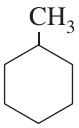
Classification of compound II _____ (Record in the **fourth** column)

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

Use the following information to answer the next question.

The following structural diagrams represent organic compounds with common industrial uses.

1



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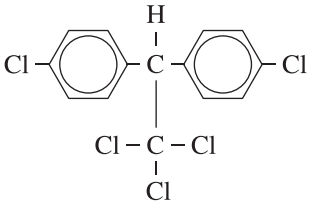

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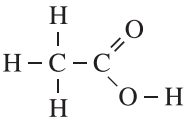
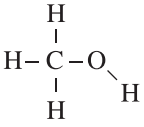


4



Numerical Response

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

Alcohol _____ (Record in the **first** column)

Aromatic _____ (Record in the **second** column)

Carboxylic acid _____ (Record in the **third** column)

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

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

Use the following information to answer the next question.

Organic Compounds

1	3-methylcyclohexene	**4**	5-ethylhept-3-yne
2	1,2-dibromopentane	**5**	cyclopropane
3	2,2-dimethylbutane	**6**	butan-1-ol

Numerical Response

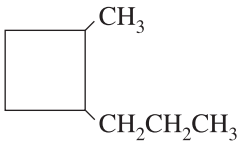
11. The organic compound numbered above that

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

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

Use the following information to answer the next question.

A student drew the structural diagram shown below.



27. *The IUPAC name for the structural diagram the student drew is 1-___**i**___-2-___**ii**___ .*

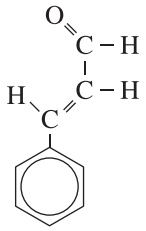
The statement above is completed by the information in row

Row	*i*	*ii*
A.	methyl	propylbutane
B.	methyl	propylcyclobutane
C.	propyl	methylbutane
D.	propyl	methylcyclobutane

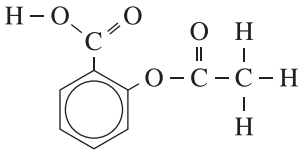
Use the following information to answer the next question.

Compounds

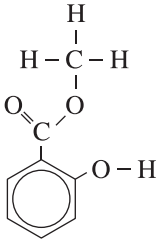
I



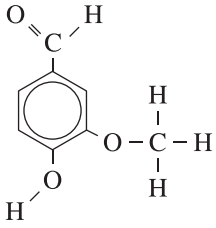
III



II



IV



28. An ester functional group is found in

A. II and III only

B. II, III, and IV

C. III only

D. IV only

29. Which of the following solutions has the **lowest** pH?

A. 1.5 mol/L $H_3PO_4(aq)$

B. 0.50 mol/L $HNO_3(aq)$

C. 0.75 mol/L $H_2CO_3(aq)$

D. 1.0 mol/L HCOOH(aq)

Use the following information to answer the next two questions.

The Haber process for the production of ammonia was developed by Fritz Haber in 1913 and is represented by the following equation.

$$N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g) + \text{energy}$$

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

The statement above is completed by the information in row

Row	***i***	***ii***
A.	increased	increased
B.	increased	decreased
C.	decreased	increased
D.	decreased	decreased

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

The statement above is completed by the information in row

Row	***i***	***ii***
A.	shifts right	increases
B.	shifts right	does not change
C.	does not change	increases
D.	does not change	does not change

Use the following information to answer the next three questions.

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

$$\underset{\text{colourless}}{H_2(g)} + \underset{\text{purple}}{I_2(g)} + 53.0\ kJ \rightleftharpoons 2\,\underset{\text{colourless}}{HI(g)}$$

At equilibrium, the flask contained 0.057 mmol of $H_2(g)$, 1.07 mmol of $I_2(g)$, and 1.87 mmol of HI(g).

32. Which of the following changes, when applied to this equilibrium system, would change the value of the equilibrium constant?

A. An addition of a catalyst

B. An increase in temperature

C. An addition of hydrogen gas

D. A decrease in the volume of the flask

33. The value of the equilibrium constant for this system at 25 °C is

A. 57

B. 31

C. 0.033

D. 0.017

34. The empirical evidence that could be used to determine when this system reaches equilibrium is

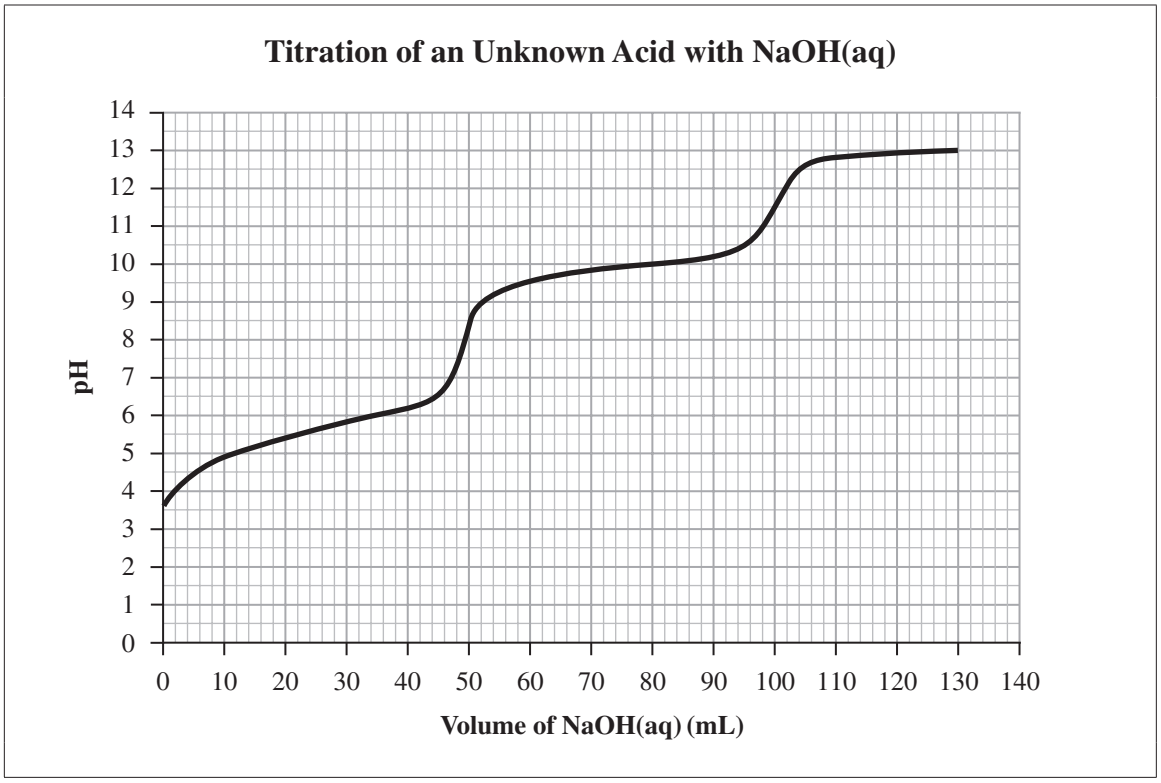
A. colour

B. density

C. total mass

D. total pressure

Use the following information to answer the next question.



35. Which of the following acids, when titrated with a 0.10 mol/L NaOH(aq) solution, could produce the titration curve shown above?

A. HF(aq)

B. HCl(aq)

C. $H_2SO_4(aq)$

D. $H_2CO_3(aq)$

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 amphiprotic species is

A. $H_2SO_3(aq)$

B. $HSO_3^-(aq)$

C. $HF(aq)$

D. $F^-(aq)$

Use the following information to answer the next question.

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

$$XeF_6(s) + 3\,H_2O(l) \rightarrow XeO_3(aq) + 6\,HF(aq)$$

37. *During the reaction, the pH of the solution will* ___***i***___ *and the pOH of the solution will* ___***ii***___ .

The statement above is completed by the information in row

Row	***i***	***ii***
A.	increase	increase
B.	increase	decrease
C.	decrease	increase
D.	decrease	decrease

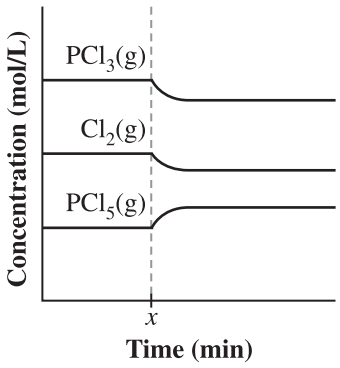
Use the following information to answer the next two questions.

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

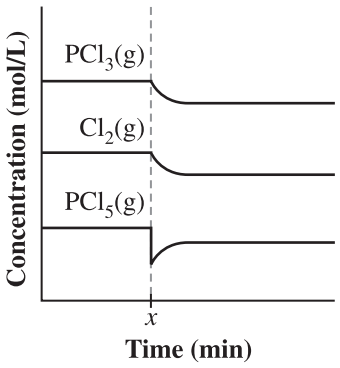
$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g) + 87.9\ kJ \qquad K_c = 1.90$$

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

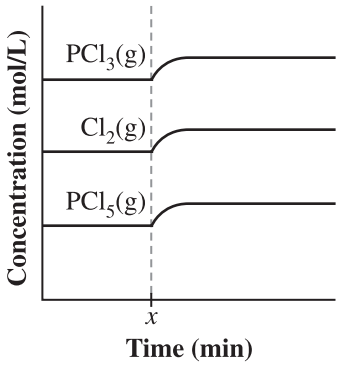
A.



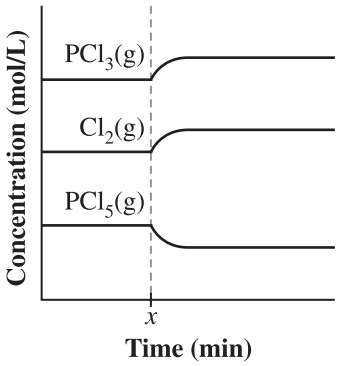
B.



C.



D.



Numerical Response

12. At equilibrium, if the concentration of $PCl_3(g)$ is 0.165 mol/L and the concentration of $PCl_5(g)$ is 0.255 mol/L, then the equilibrium concentration of $Cl_2(g)$, expressed in scientific notation, is $\boldsymbol{a.bc} \times 10^{-\boldsymbol{d}}$ mol/L. The values of $\boldsymbol{a}$, $\boldsymbol{b}$, $\boldsymbol{c}$, and $\boldsymbol{d}$ are _____, _____, _____, and _____.

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

40. *Sulfurous acid is a* ___***i***___ *acid, and its conjugate base is* ___***ii***___ .

The statement above is completed by the information in row

Row	*i*	*ii*
A.	monoprotic	amphiprotic
B.	monoprotic	polyprotic
C.	polyprotic	amphiprotic
D.	polyprotic	polyprotic

Use the following information to answer the next question.

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

$$SO_2(g) + H_2O(l) \rightleftharpoons H_2SO_3(aq)$$

Numerical Response

13. The K_b of the conjugate base of sulfurous acid, expressed in scientific notation, is $\boldsymbol{a.b} \times 10^{-\boldsymbol{cd}}$. The values of $\boldsymbol{a}$, $\boldsymbol{b}$, $\boldsymbol{c}$, and $\boldsymbol{d}$ are _____, _____, _____, and _____.

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

Use the following information to answer the next question.

A technician prepares 500 mL of a 0.3 mol/L $NH_3(aq)$ solution.

Numerical Response

14. The pH of the $NH_3(aq)$ solution is _____ .

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

Use the following information to answer the next question.

Benzoic acid reacts with water as represented by the following equation.

$$C_6H_5COOH(aq) + H_2O(l) \rightleftharpoons C_6H_5COO^-(aq) + H_3O^+(aq)$$

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

The statement above is completed by the information in row

Row	*i*	*ii*
A.	$OH^-(aq)$	accept
B.	$OH^-(aq)$	donate
C.	$C_6H_5COO^-(aq)$	accept
D.	$C_6H_5COO^-(aq)$	donate

Use the following information to answer the next question.

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

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

A. $H_3PO_4(aq) + 3\,NaHCO_3(aq) \rightarrow Na_3PO_4(aq) + 3\,H_2CO_3(aq)$

B. $H_3PO_4(aq) + HCO_3^-(aq) \rightarrow H_2PO_4^-(aq) + H_2CO_3(aq)$

C. $H_2PO_4^-(aq) + HCO_3^-(aq) \rightarrow HPO_4^{2-}(aq) + H_2CO_3(aq)$

D. $H_2PO_4^-(aq) + 2\,HCO_3^-(aq) \rightarrow HPO_4^{2-}(aq) + 2\,H_2CO_3(aq)$

You have now completed the examination.
If you have time, you may wish to check your answers.

Chemistry 30 Diploma Examination June 2009
Part B: Multiple-Choice and Numerical-Response Answers

Key: MC–Multiple Choice; NR–Numerical Response

Question	Key	*Diff. %	Question	Key	*Diff. %
NR1	Not released	n/a	**MC23**	A	64.3
MC1	A	58.8	**MC24**	A	44.2
MC2	C	75.4	**NR7**	1347 (any order)	75.8
MC3	D	71.8	**MC25**	D	76.0
MC4	B	60.5	**MC26**	B	83.7
NR2	2212	63.9	**NR8**	Not released	n/a
MC5	D	84.2	**NR9**	8235	55.4
MC6	B	63.4	**NR10**	4232	27.6
MC7	B	74.1	**NR11**	1645	87.3
MC8	C	61.3	**MC27**	B	82.1
MC9	C	63.9	**MC28**	A	64.5
NR3	83.6 or 83.7	64.2	**MC29**	B	58.7
NR4	2466	83.1	**MC30**	B	61.0
MC10	Deleted	n/a	**MC31**	D	72.2
MC11	D	76.3	**MC32**	B	61.2
NR5	3523	43.1	**MC33**	A	70.4
MC12	C	60.7	**MC34**	A	84.9
MC13	A	84.5	**MC35**	D	62.5
MC14	D	78.0	**MC36**	B	72.4
MC15	D	72.2	**MC37**	C	61.5
MC16	A	67.1	**MC38**	Not released	n/a
MC17	A	72.2	**MC39**	D	65.9
MC18	C	54.7	**NR12**	8131	49.1
MC19	A	74.9	**MC40**	C	72.8
MC20	D	56.5	**NR13**	7113	68.6
MC21	C	72.4	**NR14**	11.4	18.9
NR6	4122	36.2	**MC41**	C	69.7
MC22	A	71.4	**MC42**	C	60.5

*Difficulty–percentage of students answering the question correctly