Answer Key - Ijersland.

Per. 1 ✓
Per 7 ✓

CONSTRUCTED RESPONSE REVIEW: Matter and Energy

January 2010

Base your answers to questions 53 through 55 on the information below.

A phase change for carbon dioxide that occurs spontaneously at 20.°C and 1.0 atmosphere is represented by the balanced equation below.

$$CO_2(s) + \text{energy} \longrightarrow CO_2(g)$$

53 Write the name of this phase change. [1]

54 Describe what happens to the potential energy of the CO_2 molecules as this phase change occurs. [1]

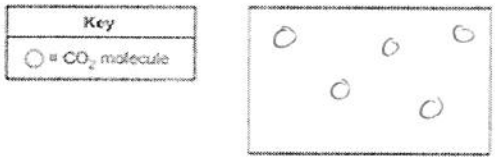
55 *In your answer booklet,* use the key to draw *at least five* molecules in the box to represent CO_2 after this phase change is completed. [1]

Answers:

53. sublimation

54. PE increases

55



August 2010

Base your answers to questions 57 and 58 on the information below.

Heat is added to a sample of liquid water, starting at 80.°C, until the entire sample is a gas at 120.°C. This process, occurring at standard pressure, is represented by the balanced equation below.

$$H_2O(\ell) + \text{heat} \rightarrow H_2O(g)$$

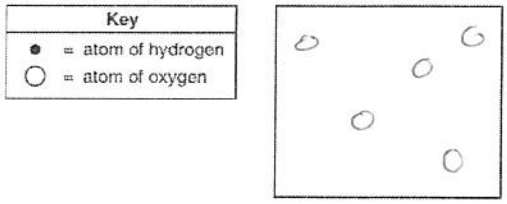
57 In the box *in your answer booklet*, using the key, draw a particle diagram to represent *at least five* molecules of the product of this physical change at 120.°C. [2]

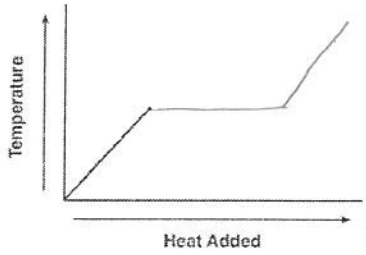
58 On the diagram *in your answer booklet*, complete the heating curve for this physical change. [1]

why is a phase change a physical change?

58

57





/

January 2011

Base your answers to questions 72 through 74 on the information below.

Cold packs are used to treat minor injuries. Some cold packs contain $NH_4NO_3(s)$ and a small packet of water at room temperature before activation. To activate this type of cold pack, the small packet must be broken to mix the water and $NH_4NO_3(s)$. The temperature of this mixture decreases to approximately 2°C and remains at this temperature for 10 to 15 minutes.

72 State the direction of heat flow that occurs when the activated cold pack is applied to the body. [1]

hot → cold.

73 Identify *both* types of bonds in the $NH_4NO_3(s)$. [1] * any time there is a polyatomic!

74 Identify the type of mixture formed when the $NH_4NO_3(s)$ is completely dissolved in the water. [1]

→ homogeneous.

Answers:

72. heat flows from the body to the cold pack.

73. ionic and covalent.

74. homogeneous

Per 1
Per 7

CONSTRUCTED RESPONSE REVIEW: Atomic Structure

June 2009

Base your answers to questions 63 through 65 on the information below.

Naturally Occurring Isotopes of Sulfur

Isotope	Atomic Mass (atomic mass units, u)	Natural Abundance (%)
^{32}S	31.97	94.93
^{33}S	32.97	0.76
^{34}S	33.97	4.29
^{36}S	35.97	0.02

63 State, in terms of the number of subatomic particles, *one* similarity and *one* difference between the atoms of these isotopes of sulfur. [1]

p, n, e

64 In the space *in your answer booklet*, draw a Lewis electron-dot diagram for an atom of sulfur-33. [1]

valence e⁻.

65 In the space *in your answer booklet*, show a correct numerical setup for calculating the atomic mass of sulfur. [1]

Answers:

63. same # protons
different # neutrons.

64. ·S·

65. (.9493 × 31.97) + (.0076 × 32.97) + (.0429 × 33.97) + (.0002 × 35.97)

Base your answers to questions 66 and 67 on the information below.

In 1897, J. J. Thomson demonstrated in an experiment that cathode rays were deflected by an electric field. This suggested that cathode rays were composed of negatively charged particles found in all atoms. Thomson concluded that the atom was a positively charged sphere of almost uniform density in which negatively charged particles were embedded. The total negative charge in the atom was balanced by the positive charge, making the atom electrically neutral.

In the early 1900s, Ernest Rutherford bombarded a very thin sheet of gold foil with alpha particles. After interpreting the results of the gold foil experiment, Rutherford proposed a more sophisticated model of the atom.

66 State *one* conclusion from Rutherford's experiment that contradicts one conclusion made by Thomson. [1]

67 State *one* aspect of the modern model of the atom that agrees with a conclusion made by Thomson. [1]

Thomson's model drawn after Rutherford

Answers:

66. small dense nucleus
OR
mostly empty space

67. all atoms contain e⁻
#p = # e⁻

January 2011

53 Copper has two naturally occurring isotopes. Information about the two isotopes is shown in the table below.

Naturally Occurring Isotopes of Copper

Isotope	Atomic Mass (atomic mass units, u)	Percent Natural Abundance (%)
Cu-63	62.93	69.17
Cu-65	64.93	30.83

In the space *in your answer booklet*, show a numerical setup for calculating the atomic mass of copper. [1]

? do you have to solve?
NO

Answer to Question 53

(.6917 × 62.93) +
(.3083 × 64.93)

January 2010

Base your answers to questions 61 through 63 on the information below.

The atomic and ionic radii for sodium and chlorine are shown in the table below.

Atomic and Ionic Radii

Particle	Radius (pm)
Na atom	190.
Na^+ ion	102
Cl atom	97
Cl^- ion	181

2-8-7

2-8-8

61 Write the ground state electron configuration for the ion that has a radius of 181 picometers. [1] lowest possible energy state.

62 Convert the radius of an Na^+ ion to meters. [1] Table C

63 Explain, in terms of atomic structure, why the radius of an Na atom is larger than the radius of an Na^+ ion. [1]

Answers:

61. 2-8-8

62. 1.02×10^{-10} m

63. Na is larger than Na^+ b/c Na^+ has lost e- and has fewer occupied energy levels.

Base your answers to questions 64 and 65 on the information below.

The nucleus of one boron atom has five protons and four neutrons.

64 Determine the total number of electrons in the boron atom. [1] neutral

#p = #e

65 Determine the total charge of the boron nucleus. [1] nuclear charge = # protons.

Answers:

64. 5 e-

65. +5

August 2010

51 *In your answer booklet*, write an electron configuration for a silicon atom in an excited state. [1]

2-8-4

* cannot exceed 8 in n=2.

Answer to Question 51

2-7-3

Base your answers to questions 59 and 60 on the information below.

In the gold foil experiment, a thin sheet of gold was bombarded with alpha particles. Almost all the alpha particles passed straight through the foil. Only a few alpha particles were deflected from their original paths.

59 State *one* conclusion about atomic structure based on the observation that almost all alpha particles passed straight through the foil. [1]

60 Explain, in terms of charged particles, why some of the alpha particles were deflected. [1]

Answers:

59. mostly empty space.

60. positively charged nucleus deflects positive alpha particles.

Per 7

CONSTRUCTED RESPONSE REVIEW: Periodic Table

August 2010

Base your answers to questions 52 and 53 on the information below.

Densities of Group 14 Elements

Element	Density at STP (g/cm^3)
C	3.51
Si	2.33
Ge	5.32
Sn	7.31
Pb	11.35

52 Identify *one* element from this table for *each* type of element: metal, metalloid, and nonmetal. [1]

53 Calculate the volume of a tin block that has a mass of 95.04 grams at STP. Your response must include *both* a numerical setup and the calculated result. [2]

Base your answers to questions 54 through 56 on the elements in Group 2 on the Periodic Table.

54 State the general trend in first ionization energy for the elements in Group 2 as these elements are considered in order from top to bottom in the group. [1]

55 State, in terms of the number of electron shells, why the radius of a strontium atom in the ground state is larger than the radius of a magnesium atom in the ground state. [1]

56 Explain, in terms of atomic structure, why the elements in Group 2 have similar chemical properties. [1]

Answers:

52. metal: Sn or Pb
nonmetal: C
metalloid: Si or Ge

53. $D = \frac{m}{V}$

$7.319\ g/cm^3 = \frac{95.04g}{x}$

13.0 cm^3

Answers:

54. As atomic number increases, ionization energy decreases.

55. A strontium atom has more occupied shells than magnesium.

56. Elements in group 2 all have 2 valence e-.

August 2007

Base your answers to questions 67 through 69 on the information below.

Elements with atomic numbers 112 and 114 have been produced and their IUPAC names are pending approval. However, an element that would be put between these two elements on the Periodic Table has not yet been produced. If produced, this element will be identified by the symbol Uut until an IUPAC name is approved.

67 In the space *in your answer booklet*, draw a Lewis electron-dot diagram for an atom of Uut. [1]

68 Determine the charge of an Uut nucleus. Your response must include *both* the numerical value and the sign of the charge. [1]

69 Identify *one* element that would be chemically similar to Uut. [1]

Answers:

67. Uut

68. +113

69. B or Al or Ga or In or Tl

June 2007

Base your answers to questions 73 through 76 on the information below.

The table below lists physical and chemical properties of six elements at standard pressure that correspond to known elements on the Periodic Table. The elements are identified by the code letters, *D*, *E*, *G*, *J*, *L*, and *Q*.

Properties of Six Elements at Standard Pressure

Element D Density 0.00018 g/cm^3 Melting point –272°C Boiling point –269°C Oxide formula (none)	Element E Density 1.82 g/cm^3 Melting point 44°C Boiling point 280°C Oxide formula E_2O_5	Element G Density 0.53 g/cm^3 Melting point 181°C Boiling point 1347°C Oxide formula G_2O
Element J Density 0.0013 g/cm^3 Melting point –210°C Boiling point –196°C Oxide formula J_2O_5	Element L Density 0.86 g/cm^3 Melting point 64°C Boiling point 774°C Oxide formula L_2O	Element Q Density 0.97 g/cm^3 Melting point 98°C Boiling point 883°C Oxide formula Q_2O

73 What is the total number of elements in the "Properties of Six Elements at Standard Pressure" table that are solids at STP? [1]

E, G, L, Q — melting point is higher than 0°C

74 An atom of element *G* is in the ground state. What is the total number of valence electrons in this atom? [1]

outermost — since G_2O (+1, −2)

75 Letter Z corresponds to an element on the Periodic Table other than the six listed elements. Elements *G*, *Q*, *L*, and Z are in the same group on the Periodic Table, as shown in the diagram below.

G	181°C
Q	98°C
L	64°C
Z	

Based on the trend in the melting points for elements *G*, *Q*, and *L* listed in the "Properties of Six Elements at Standard Pressure" table, estimate the melting point of element Z, in degrees Celsius. [1]

76 Identify, by code letter, the element that is a noble gas in the "Properties of Six Elements at Standard Pressure" table. [1]

unreactive.

Answers:

73 4

74 ~~0~~ 1

75 Any value under 64 °C

76 D

no oxide formula →

CONSTRUCTED RESPONSE REVIEW: Bonding and Nomenclature

January 2010

Base your answers to questions 76 through 78 on the information below.

Carbon has three naturally occurring isotopes, C-12, C-13, and C-14. Diamond and graphite are familiar forms of solid carbon. Diamond is one of the hardest substances known, while graphite is a very soft substance. Diamond has a rigid network of bonded atoms. Graphite has atoms bonded in thin layers that are held together by weak forces.

Recent experiments have produced new forms of solid carbon called fullerenes. One fullerene, C_{60}, is a spherical, cagelike molecule of carbon.

76 Determine *both* the total number of protons and the total number of neutrons in an atom of the naturally occurring carbon isotope with the largest mass number. [1]

77 Identify the type of bonding in a fullerene molecule. [1]

78 State, in terms of the arrangement of atoms, the difference in hardness between diamond and graphite. [1]

Answers:

76.

Protons: 6

Neutrons: 8

77. covalent.

78. graphite is layers while diamond is a network.

January 2011

51 Explain, in terms of electronegativity difference, why the bond in a molecule of HF is more polar than the bond in a molecule of HI. [1]

Answer to Question #51

There is a greater Eneg diff between H-F than H-I.

Base your answers to questions 54 and 55 on the information below.

In an experiment, 2.54 grams of copper completely reacts with sulfur, producing 3.18 grams of copper(I) sulfide.

54 Determine the total mass of sulfur consumed. [1]

$3.18 - 2.54 = .64$

55 Write the chemical formula of the compound produced. [1]

Answers:

54 .64g g

55 Cu_2S

Base your answers to questions 56 and 67 on the information below.

Physical Properties of CF_4 and NH_3 at Standard Pressure

Compound	Melting Point (°C)	Boiling Point (°C)	Solubility in Water at 20.0°C
CF_4	−183.6	−127.8	insoluble
NH_3	−77.7	−33.3	soluble

56 State evidence that indicates NH_3 has stronger intermolecular forces than CF_4. [1]

57 In the space *in your answer booklet*, draw a Lewis electron-dot diagram for CF_4. [1]

Answers:

56. NH_3 has a higher mp than CF_4

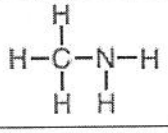
57.

August 2009

Base your answers to questions 59 through 63 on the information below.

Bond energy is the amount of energy required to break a chemical bond. The table below gives a formula and the carbon-nitrogen bond energy for selected nitrogen compounds.

Selected Nitrogen Compounds

Compound	Formula	Carbon-Nitrogen Bond Energy (kJ/mol)
hydrogen cyanide	H–C≡N	890.
isocyanic acid	H–N=C=O	615
methanamine		293

59 Describe, in terms of electrons, the type of bonding between the carbon atom and the nitrogen atom in a molecule of methanamine. [1]

60 Identify the noble gas that has atoms in the ground state with the same electron configuration as the nitrogen in a molecule of isocyanic acid. [1]

61 State the relationship between the number of electrons in a carbon-nitrogen bond and carbon-nitrogen bond energy. [1]

62 Explain, in terms of charge distribution, why a molecule of hydrogen cyanide is polar. [1]

63 A 3.2-gram sample of air contains 0.000 74 gram of hydrogen cyanide. Determine the concentration, in parts per million, of the hydrogen cyanide in this sample. [1]

Answers:

59. C-N has a single covalent bond by sharing one pair of e⁻.

60. Ne

61. As # C-N bonds ↑, bond energy ↑.

62. There is an asymmetrical distribution of charge.

63. 231.25 ppm $\frac{.00074}{3.2} \times 10^6$

CONSTRUCTED RESPONSE REVIEW: Moles and Stoichiometry

June 2009

Base your answers to questions 79 through 83 on the information below.

Arsenic is often obtained by heating the ore arsenopyrite, FeAsS. The decomposition of FeAsS is represented by the balanced equation below.

125g
$$FeAsS(s) \xrightarrow{heat} FeS(s) + As(g)$$
67.5g + x

Law of Cons. of Mass

In the solid phase, arsenic occurs in two forms. One form, yellow arsenic, has a density of 1.97 g/cm^3 at STP. The other form, gray arsenic, has a density of 5.78 g/cm^3 at STP. When arsenic is heated rapidly in air, arsenic(III) oxide is formed.

Although arsenic is toxic, it is needed by the human body in very small amounts. The body of a healthy human adult contains approximately 5 milligrams of arsenic.

79 Convert the mass of arsenic found in the body of a healthy human adult to grams. [1]

5 mg x 1g/1000mg = .005g

80 When heated, a 125.0-kilogram sample of arsenopyrite yields 67.5 kilograms of FeS. Determine the total mass of arsenic produced in this reaction. [1]

81 Write the formula for the compound produced when arsenic is heated rapidly in air. [1]

See reading

82 Explain, in terms of the arrangement of atoms, why the two forms of arsenic have different densities at STP. [1]

83 Calculate the percent composition by mass of arsenic in arsenopyrite. Your response must include *both* a correct numerical setup and the calculated result. [2]

Answers:

79. .005 g

80. 57.5 kg

81. As_2O_3

82. The particles are arranged differently resulting in different properties. (allotropes!)

83. FeAsS

Fe = 55.8

As = 74.9

S = 32.1

162.8

74.9 / 162.8 x 100

46 %

August 2009

52 Given the balanced equation representing a reaction:

8 mol x
$$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$$

Determine the total number of moles of oxygen that react completely with 8.0 moles of C_2H_6. [1]

$$8\ mol\ C_2H_6 \left(\frac{7\ mol\ O_2}{2\ mol\ C_2H_6}\right) = 7.5\ mol$$

Answer to Question 52

7.5 mol

55 Determine the mass of 5.20 moles of C_6H_{12} (gram-formula mass = 84.2 grams/mole). [1]

$$5.20\ mol\ (84.2\ g/mol)$$

Answer to Question 55

437.84g

438g (rounded to s.f)

OR

$$\frac{2\ mol\ C_2H_6}{7\ mol\ O_2} = \frac{8\ mol\ C_2H_6}{x\ mol\ O_2}$$

August 2008

Base your answers to questions 73 through 76 on the information below.

A portable propane-fueled lantern contains a mesh silk bag coated with metal hydroxides. The primary metal hydroxide is yttrium hydroxide. When the silk bag is installed, it is ignited and burned away, leaving the metal hydroxide coating. The coating forms metal oxides that glow brightly when heated to a high temperature.

During a test, a propane lantern is operated for three hours and consumes 5.0 moles of propane from the lantern's tank. The balanced equation below represents the combustion of propane.

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O + \text{energy}$$

73 At standard pressure, the boiling point of propane is 231 K. In the box *in your answer booklet*, draw a particle diagram to represent the phase of the propane as it leaves the tank at 294 K. Your response must include *at least six* molecules. [1]

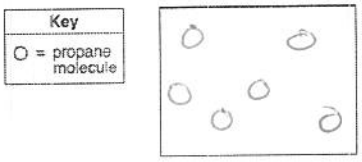
74 Calculate the total mass of propane consumed during the lantern test. Your response must include *both* a correct numerical setup and the calculated result. [2]

75 Determine the total number of moles of CO_2 produced during the lantern test. [1]

76 Write the formula for the primary metal hydroxide used in the lantern. [1]

Answers:

73.



74. 220 g

75. 25 mol

76. $Y(OH)_3$

January 2011

Base your answers to questions 69 through 71 on the information below.

A tablet of one antacid contains citric acid, $H_3C_6H_5O_7$, and sodium hydrogen carbonate, $NaHCO_3$. When the tablet dissolves in water, bubbles of CO_2 are produced. This reaction is represented by the incomplete equation below.

$$H_3C_6H_5O_7(aq) + 3NaHCO_3(aq) \rightarrow Na_3C_6H_5O_7(aq) + 3CO_2(g) + 3\ \underline{\quad}\ (\ell)$$

69 Complete the equation *in your answer booklet* by writing the formula of the missing product. [1]

70 State evidence that a chemical reaction occurred when the tablet was placed in the water. [1]

71 Determine the total number of moles of sodium hydrogen carbonate that will completely react with 0.010 mole of citric acid. [1]

Answers:

69 $H_3C_6H_5O_7(aq) + 3NaHCO_3(aq) \rightarrow Na_3C_6H_5O_7(aq) + 3CO_2(g) + 3\ H_2O\ (\ell)$

70 bubbles of CO_2 are produced.

71 .03 mol

CONSTRUCTED RESPONSE REVIEW: Gas Laws

June 2007

Base your answers to questions 51 through 53 on the information below.

A gas sample is held at constant temperature in a closed system. The volume of the gas is changed, which causes the pressure of the gas to change. Volume and pressure data are shown in the table below.

Volume and Pressure of a Gas Sample

Volume (mL)	Pressure (atm)
1200	0.5
600	1.0
300	2.0
150	4.0
100	6.0

51 On the grid *in your answer booklet*, mark an appropriate scale on the axis labeled "Volume (mL)." [1]

52 On the same grid, plot the data from the table. Circle and connect the points. [1]

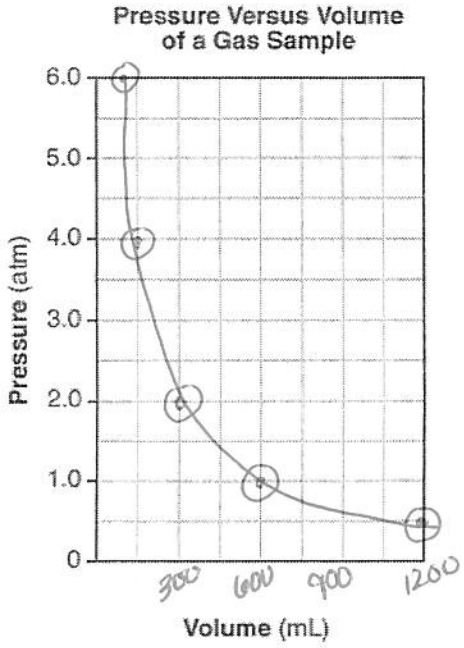
Example: 

53 Based on your graph, what is the pressure of the gas when the volume of the gas is 200. milliliters? [1]

_____

Answers:

51-52.



53. 3.0 atm (approx.)

//

63 A 1.00-mole sample of neon gas occupies a volume of 24.4 liters at 298 K and 101.3 kilopascals. In the space *in your answer booklet*, calculate the density of this sample. Your response must include *both* a correct numerical setup and the calculated result. [2]

Answer to Question 63

$D = \frac{m}{V}$ $\frac{20.18\text{g}}{24.4\text{L}}$

1 mol Ne = 20.18 g

.827 g/L

June 2009

Base your answers to questions 51 through 53 on the information below.

A sample of helium gas is in a closed system with a movable piston. The volume of the gas sample is changed when both the temperature and the pressure of the sample are increased. The table below shows the initial temperature, pressure, and volume of the gas sample, as well as the final temperature and pressure of the sample.

Helium Gas in a Closed System

Condition	Temperature (K)	Pressure (atm)	Volume (mL)
initial	200.	2.0	500.
final	300.	7.0	?

51 In the space *in your answer booklet*, show a correct numerical setup for calculating the final volume of the helium gas sample. [1]

52 Convert the final temperature of the helium gas sample to degrees Celsius. [1]

53 Compare the total number of gas particles in the sample under the initial conditions to the total number of gas particles in the sample under the final conditions. [1]

Answers:

51 $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $\frac{(2.0\text{ atm})(500.\text{mL})}{200.\text{K}} = \frac{(7.0\text{atm})(x)}{300.\text{K}}$

52 27 °C $K = °C + 273$ $300 - 273 = 27°C$

53 the total number of gas particles are the same because it is a closed system. *

CONSTRUCTED RESPONSE REVIEW: Kinetics and Equilibrium

June 2009

Base your answers to questions 58 and 59 on the information below.

At a pressure of 101.3 kilopascals and a temperature of 373 K, heat is removed from a sample of water vapor, causing the sample to change from the gaseous phase to the liquid phase. This phase change is represented by the equation below.

$$H_2O(g) \rightarrow H_2O(\ell) + \text{heat}$$

58 Explain, in terms of particle arrangement, why entropy *decreases* during this phase change. [1]

59 Determine the total amount of heat released by 5.00 grams of water vapor during this phase change. [1] g→l condensation = opposite of vaporization

Answers:

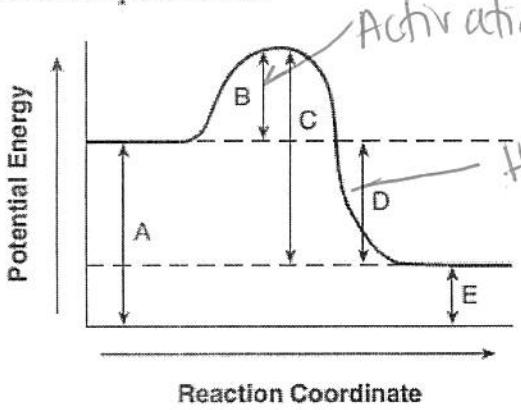
58. particles of a liquid are more closely packed than particles in the gas phase.

59. 11300 J $q = mH_v$ $(5.00g)(2260J/g)$

January 2011

Base your answers to questions 60 and 61 on the information below.

The chemical reaction between methane and oxygen is represented by the potential energy diagram and balanced equation below.



$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(\ell) + 890.4\ \text{kJ}$$

60 Which potential energy interval in the diagram represents the activation energy of the forward reaction? [1]

61 Explain, in terms of collision theory, why a lower concentration of oxygen gas *decreases* the rate of this reaction. [1]

60. B

61. The rate will decrease due to a lower frequency of collisions.

January 2010

Base your answers to questions 72 through 75 on the information below.

An experiment is performed to determine how concentration affects the rate of reaction. In each of four trials, equal volumes of solution *A* and solution *B* are mixed while temperature and pressure are held constant. The concentration of solution *B* is held constant, but the concentration of solution *A* is varied. The concentration of solution *A* and the time for the reaction to go to completion for each trial are recorded in the data table below.

Data Table

Trial	Concentration of Solution A (M)	Reaction Time (s)
1	0.0200	4.5
2	0.0150	7.0
3	0.0100	12.0
4	0.0050	20.0

Be careful asks for time not rate.

72 Describe the relationship between the concentration of solution *A* and the time for the reaction to go to completion. [1]

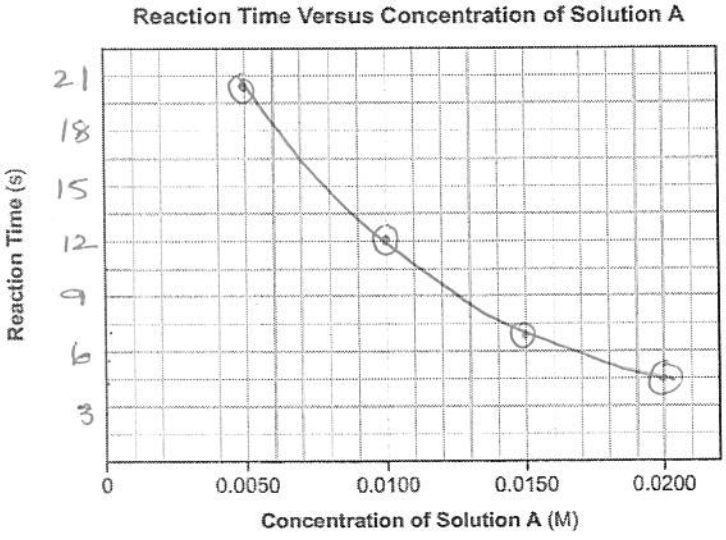
73 On the grid *in your answer booklet*, mark an appropriate scale on the axis labeled "Reaction Time (s)." [1]

74 On the same grid, plot the data from the data table. Circle and connect the points. [1]

75 Identify *one* factor, other than the concentration of the solutions, that can affect the rate of this reaction. [1]

_____

73 and 74



Answers:

72. As concentration decreases, time increases. (or vice versa)

75. temperature

CONSTRUCTED RESPONSE REVIEW : Solutions

June 2009

Base your answers to questions 71 through 73 on the information below.

A soft-drink bottling plant makes a colorless, slightly acidic carbonated beverage called soda water. During production of the beverage, $CO_2(g)$ is dissolved in water at a pressure greater than 1 atmosphere. The bottle containing the solution is capped to maintain that pressure above the solution. As soon as the bottle is opened, fizzing occurs due to $CO_2(g)$ being released from the solution.

71 Explain why $CO_2(g)$ is released when a bottle of soda water is opened. [1]

72 Write the chemical name of the acid in soda water. [1]

73 State the relationship between the solubility of $CO_2(g)$ in water and the temperature of the aqueous solution. [1]

Answers:

71. As pressure decreases solubility of a gas decreases.

72. carbonic acid

73. As temp. inc. solubility of $CO_2(g)$ in water decreases.

January 2010

Table G

$\frac{\text{Approx. } 56\text{g } NH_3}{100\text{g } H_2O} = \frac{x}{200\text{g } H_2O}$

51 Based on Table *G*, determine the total mass of NH_3 that must be dissolved in 200. grams of water to produce a saturated solution at 20.°C. [1]

Question #51

112 g NH_3

Base your answers to questions 56 and 57 on the information below.

The dissolving of solid lithium bromide in water is represented by the balanced equation below.

$$LiBr(s) \xrightarrow{H_2O} Li^+(aq) + Br^-(aq)$$

56 Calculate the total mass of LiBr(s) required to make 500.0 grams of an aqueous solution of LiBr that has a concentration of 388 parts per million. Your response must include *both* a correct numerical setup and the calculated result. [2]

57 Based on Table *F*, identify *one* ion that reacts with Br^- ions in an aqueous solution to form an insoluble compound. [1]

56.

$\frac{388 \text{ ppm}}{10^6} = \frac{x}{500.0\text{g}}$

$x = .194\text{ g}$

57. Ag^+ (or Pb^{2+} or Hg_2^{2+})

January 2011

Base your answers to questions 58 and 59 on the information below.

A 2.0-liter aqueous solution contains a total of 3.0 moles of dissolved NH_4Cl at 25°C and standard pressure.

58 Determine the molarity of the solution. [1]

59 Identify the *two* ions present in the solute. [1]

58.

$M = \frac{\text{mol}}{L} = \frac{3.0 \text{ mol}}{2.0 L}$

$M = 1.5M$

59. NH_4^+ and Cl^-

August 2010

Base your answers to questions 61 through 63 on the information below.

Some Properties of Three Compounds at Standard Pressure

Compound	Boiling Point (°C)	Solubility in 100. Grams of H_2O at 20.°C (g)
ammonia	–33.2	56
methane	–161.5	0.002
hydrogen chloride	–84.9	72

61 Convert the boiling point of hydrogen chloride at standard pressure to kelvins. [1]

62 Explain, in terms of molecular polarity, why hydrogen chloride is more soluble than methane in water at 20.°C and standard pressure. [1]

63 Explain, in terms of intermolecular forces, why ammonia has a higher boiling point than the other compounds in the table. [1]

61. $K = 273 + °C$ $-84.9 + 273 =$

62. Hydrogen chloride is more polar than methane.

63. Ammonia has stronger intermolecular forces resulting in a higher boiling point.

Base your answers to questions 70 through 72 on the information below.

Hydrogen peroxide, H_2O_2, is a water-soluble compound. The concentration of an aqueous hydrogen peroxide solution that is 3% by mass H_2O_2 is used as an antiseptic. When the solution is poured on a small cut in the skin, H_2O_2 reacts according to the balanced equation below.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

70 Identify the type of chemical reaction represented by the balanced equation. [1]

70. decomposition

71 Calculate the total mass of H_2O_2 in 20.0 grams of an aqueous H_2O_2 solution that is used as an antiseptic. Your response must include *both* a numerical setup and the calculated result. [2]

72 Determine the gram-formula mass of H_2O_2. [1]

71. $\frac{x\ g\ H_2O_2}{20.0\ g\ H_2O_2} = \frac{3}{100}$

$x = 6\ g\ H_2O_2$

72. H $2 \times 1.0 = 2.0$

O $2 \times 16.0 = 32.0$

34.0 g

CONSTRUCTED RESPONSE PRACTICE: Acids and Bases

June 2009

Base your answers to questions 77 and 78 on the information below.

In performing a titration, a student adds three drops of phenolphthalein to a flask containing 25.00 milliliters of HCl(aq). Using a buret, the student slowly adds 0.150 M NaOH(aq) to the flask until one drop causes the indicator to turn light pink. The student determines that a total volume of 20.20 milliliters of NaOH(aq) was used in this titration.

77 The concentration of the NaOH(aq) used in the titration is expressed to what number of significant figures? [1]

78 Calculate the molarity of the HCl(aq) used in this titration. Your response must include *both* a correct numerical setup and the calculated result. [2]

Answers:

77. 3

78. $(25.00mL)x = (.150M)(20.20)$

$\frac{25.00x}{25.00} = \frac{3.03}{25.00}$

$x = .1212\ M$

August 2010

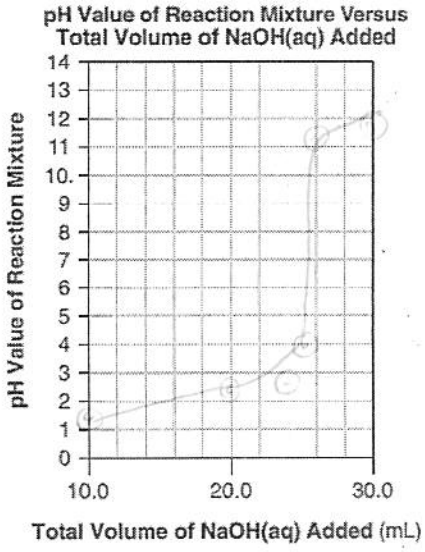
Base your answers to questions 75 through 78 on the information below.

In one trial of an investigation, 50.0 milliliters of HCl(aq) of an unknown concentration is titrated with 0.10 M NaOH(aq). During the titration, the total volume of NaOH(aq) added and the corresponding pH value of the reaction mixture are measured and recorded in the table below.

Titration Data

Total Volume of NaOH(aq) Added (mL)	pH Value of Reaction Mixture
10.0	1.6
20.0	2.2
24.0	2.9
24.9	3.9
25.1	10.1
26.0	11.1
30.0	11.8

75 On the grid *in your answer booklet*, plot the data from the table. Circle and connect the points. [1]



76 Determine the total volume of NaOH(aq) added when the reaction mixture has a pH value of 7.0. [1]

77 Write a balanced equation that represents this neutralization reaction. [1]

78 In another trial, 40.0 milliliters of HCl(aq) is completely neutralized by 20.0 milliliters of this 0.10 M NaOH(aq). Calculate the molarity of the titrated acid in this trial. Your response must include *both* a numerical setup and the calculated result. [2]

76. 25.5mL

77. $NaOH + HCl \rightarrow NaCl + H_2O$

78. $(40mL)(x) = (20mL)(.1M)$

$x = 0.05M$

January 2011

Base your answers to questions 64 and 65 on the information below.

A 20.0-milliliter sample of HCl(aq) is completely neutralized by 32.0 milliliters of 0.50 M KOH(aq).

64 Calculate the molarity of the HCl(aq). Your response must include *both* a numerical setup and the calculated result. [2]

65 According to the data, to what number of significant figures should the calculated molarity of the HCl(aq) be expressed? [1]

Answers:

64. $(20.0\,mL)(x) = (32.0\,mL)(.50M)$

$\frac{20x}{20} = \frac{16}{20}$

$x = .8M$

65. 2

Base your answers to questions 81 through 83 on the information below.

A student, wearing chemical safety goggles and a lab apron, is to perform a laboratory test to determine the pH value of two different solutions. The student is given one bottle containing a solution with a pH of 2.0 and another bottle containing a solution with a pH of 5.0. The student is also given six dropping bottles, each containing a different indicator listed in Reference Table *M*.

81 State *one* safety precaution, *not* mentioned in the passage, that the student should take while performing tests on the samples from the bottles. [1]

82 Identify an indicator in Reference Table *M* that would differentiate the two solutions. [1]

83 Compare the hydronium ion concentration of the solution having a pH of 2.0 to the hydronium ion concentration of the other solution given to the student. [1]

Answers:

81. wash hands, do not smell or taste

82. methyl orange

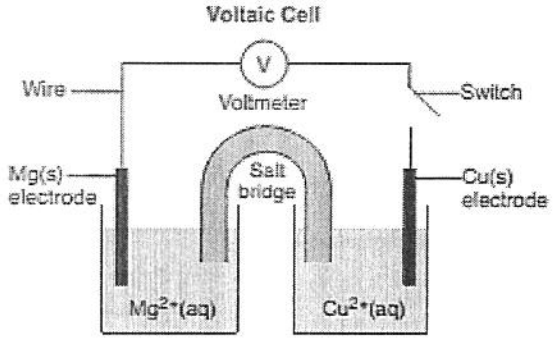
83. pH of 2.0 has a higher concentration of H_3O^+

CONSTRUCTED RESPONSE REVIEW: Redox & Electrochemistry

June 2009

Base your answers to questions 60 through 62 on the information below.

A voltaic cell with magnesium and copper electrodes is shown in the diagram below. The copper electrode has a mass of 15.0 grams.



$Mg(s) + Cu^{2+}(aq) \longrightarrow Mg^{2+}(aq) + Cu(s)$

When the switch is closed, the reaction in the cell begins. The balanced ionic equation for the reaction in the cell is shown below the cell diagram. After several hours, the copper electrode is removed, rinsed with water, and dried. At this time, the mass of the copper electrode is greater than 15.0 grams.

60 State the direction of electron flow through the wire between the electrodes when the switch is closed. [1]

61 State the purpose of the salt bridge in this cell. [1]

62 Explain, in terms of copper ions and copper atoms, why the mass of the copper electrode increases as the cell operates. Your response must include information about *both* copper ions and copper atoms. [1]

Answers:

60. Mg to Cu

61. allows for the migration of ions OR maintains a neutral cell

62. The mass of the Cu electrode increases because copper ions are being reduced into copper atoms

January 2010

Base your answers to questions 69 through 71 on the information below.

In a laboratory investigation, magnesium reacts with hydrochloric acid to produce hydrogen gas and magnesium chloride. This reaction is represented by the unbalanced equation below.

$$Mg(s) + HCl(aq) \longrightarrow H_2(g) + MgCl_2(aq)$$

69 State, in terms of the relative activity of elements, why this reaction is spontaneous. [1]

70 Balance the equation *in your answer booklet,* using the smallest whole-number coefficients. [1]

71 Write a balanced half-reaction equation for the oxidation that occurs. [1]

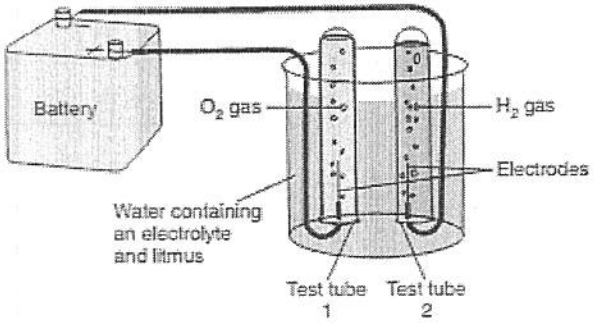
69 magnesium is more active than hydrogen.

70 ____ $Mg(s)$ + 2 $HCl(aq) \rightarrow$ ____ $H_2(g)$ + ____ $MgCl_2(aq)$

71 $Mg \rightarrow Mg^{2+} + 2e^-$

Base your answers to questions 82 through 84 on the information below.

The diagram below shows a system in which water is being decomposed into oxygen gas and hydrogen gas. Litmus is used as an indicator in the water. The litmus turns red in test tube 1 and blue in test tube 2.



The oxidation and reduction occurring in the test tubes are represented by the balanced equations below.

Test tube 1: $2H_2O(\ell) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

Test tube 2: $4H_2O(\ell) + 4e^- \rightarrow 2H_2(g) + 4OH^-(aq)$

82 Identify the information in the diagram that indicates this system is an electrolytic cell. [1]

83 Determine the change in oxidation number of oxygen during the reaction in test tube 1. [1]

84 Explain, in terms of the products formed in test tube 2, why litmus turns blue in test tube 2. [1]

Answers:

82. The presence of a battery

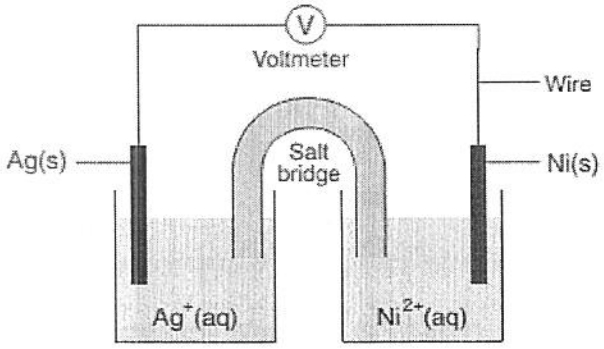
83. -2 to 0

84. The products of reaction #2 produce OH^- ions which create a basic environment

August 2010

Base your answers to questions 64 through 66 on the information below.

The diagram below represents an operating voltaic cell at 298 K and 1.0 atmosphere in a laboratory investigation. The reaction occurring in the cell is represented by the balanced ionic equation below.



$2Ag^+(aq) + Ni(s) \rightarrow 2Ag(s) + Ni^{2+}(aq)$

64 Identify the anode in this cell. [1]

65 Determine the total number of moles of $Ni^{2+}(aq)$ ions produced when 4.0 moles of $Ag^+(aq)$ ions completely react in this cell. [1]

66 Write a balanced half-reaction equation for the reduction that occurs in this cell. [1]

Answers:

64. Ni

65. 2 mol

66. $Ag^+ + e^- \rightarrow Ag$ OR $2Ag^+ + 2e^- \rightarrow 2Ag$

Base your answers to questions 73 and 74 on the information below.

The catalytic converter in an automobile changes harmful gases produced during fuel combustion to less harmful exhaust gases. In the catalytic converter, nitrogen dioxide reacts with carbon monoxide to produce nitrogen and carbon dioxide. In addition, some carbon monoxide reacts with oxygen, producing carbon dioxide in the converter. These reactions are represented by the balanced equations below.

Reaction 1: $2NO_2(g) + 4CO(g) \rightarrow N_2(g) + 4CO_2(g) + 1198.4\ kJ$

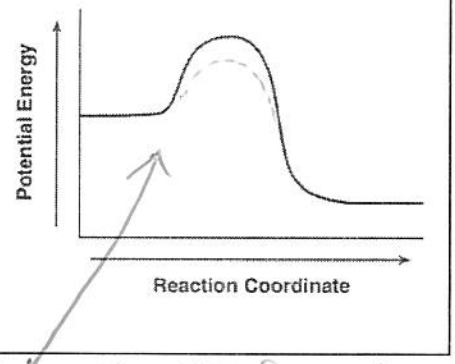
Reaction 2: $2CO(g) + O_2(g) \rightarrow 2CO_2(g) + 566.0\ kJ$

73 The potential energy diagram *in your answer booklet* represents reaction 1 without a catalyst. On the same diagram, draw a dashed line to indicate how potential energy changes when the reaction is catalyzed in the converter. [1]

— catalyst provides an alternate pathway w/ a lower activation energy

74 Determine the oxidation number of carbon in *each* carbon compound in reaction 2. Your response must include *both* the sign and value of *each* oxidation number. [1]

73.



not the PE of reactants + PE of products don't change.

74 CO: +2

CO_2: +4

January 2011

52 Explain, in terms of activity, why HCl(aq) reacts with Zn(s), but HCl(aq) does *not* react with Cu(s). [1]

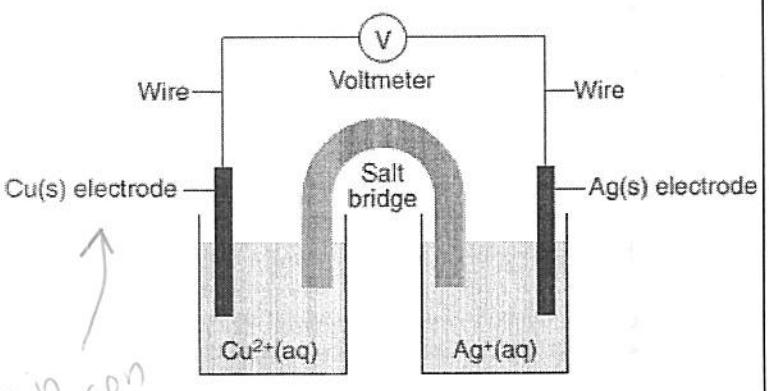
Answers to Question 52

Zn is more active than hydrogen while Cu is less active.

Base your answers to questions 62 and 63 on the information below.

The diagram and balanced ionic equation below represent a voltaic cell with copper and silver electrodes and the reaction that occurs when the cell is operating.

Voltaic Cell



anode is higher on Table J.

$$Cu(s) + 2Ag^+(aq) \longrightarrow Cu^{2+}(aq) + 2Ag(s)$$

Answers:

62. e⁻ flow from Cu to Ag

63. salt bridge allows for the migration of ions OR maintains a nutral cell.

62 Describe the direction of electron flow in the external circuit in this operating cell. [1]

anode → cathode

63 State the purpose of the salt bridge in this voltaic cell. [1]

Base your answers to questions 75 through 77 on the information below.

Litharge, PbO, is an ore that can be roasted (heated) in the presence of carbon monoxide, CO, to produce elemental lead. The reaction that takes place during this roasting process is represented by the balanced equation below.

+2 -2 +2 -2 0 +4 -2

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

GER gain OX ↓

75 Write the balanced equation for the reduction half-reaction that occurs during this roasting process. [1]

need OX #

76 Determine the oxidation number of carbon in carbon monoxide. [1]

CO

77 Calculate the percent composition by mass of oxygen in litharge (gram-formula mass = 223.2 grams per mole). Your response must include *both* a numerical setup and the calculated result. [2]

PbO (see reading)

Answers:

75 $C^{+2} \rightarrow C^{+4} + 2e^-$

76 +2

77

$$\frac{16\text{g O}}{223.2\text{g PbO}} \times 100 =$$

7.168458781

7.17 %

CONSTRUCTED RESPONSE REVIEW: Organic Chemistry

June 2009

Base your answers to questions 54 through 57 on the information below.

Molar Mass and Boiling Point of Four Substances

Substance	Molar Mass (g/mol)	Boiling Point at 1 atm (K)
methane	16	112
ethane	30.	185
propane	44	231
butane	58	273

54 On the grid *in your answer booklet*, mark an appropriate scale on the axis labeled "Boiling Point (K)." [1]

55 On the same grid, plot the data from the data table. Circle and connect the points. [1]

56 Based on the data in the table, state the relationship between the boiling point at 1 atmosphere and molar mass for these four substances. [1]

57 State, in terms of intermolecular forces, why the boiling point of propane at 1 atmosphere is *lower* than the boiling point of butane at 1 atmosphere. [1]

See next page for space to complete #54 - 57

Base your answers to questions 74 through 76 on the information below.

During a bread-making process, glucose is converted to ethanol and carbon dioxide, causing the bread dough to rise. Zymase, an enzyme produced by yeast, is a catalyst needed for this reaction.

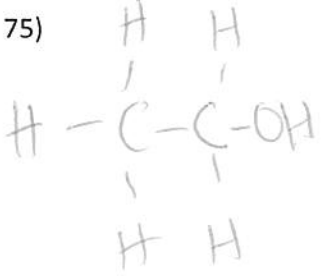
74 Balance the equation *in your answer booklet* for the reaction that causes bread dough to rise, using the smallest whole-number coefficients. [1]

75 In the space *in your answer booklet*, draw a structural formula for the alcohol formed in this reaction. [1]

76 State the effect of zymase on the activation energy for this reaction. [1]

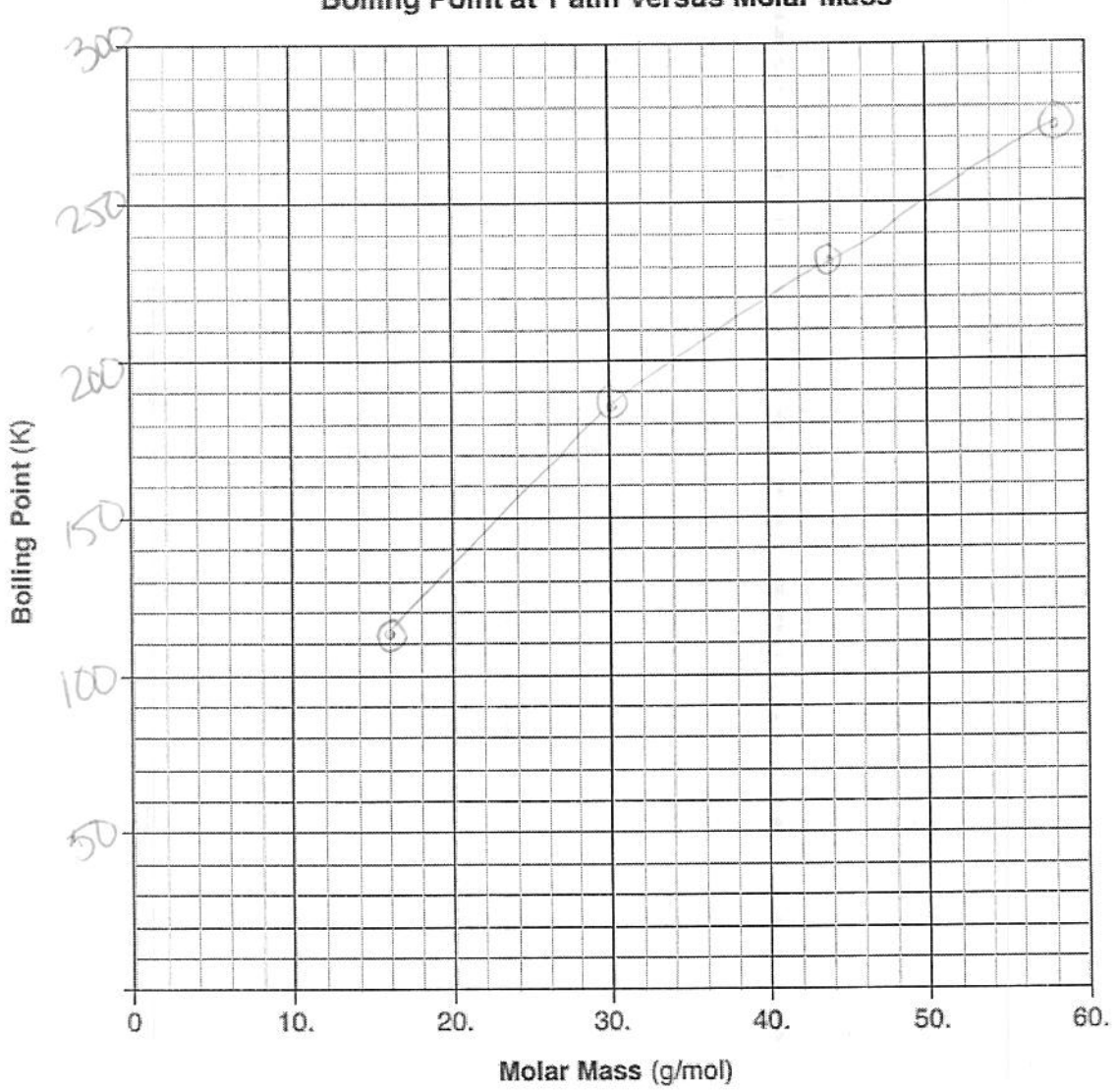
74 1 $C_6H_{12}O_6 \xrightarrow{\text{zymase}}$ 2 C_2H_5OH + 2 CO_2 + energy

75)



76) Zymase lowers the activation energy. *

54 and 55



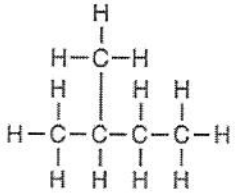
56 As molar mass increases, boiling point increases.

57 The bp of propane is lower than that of butane because propane has weaker intermolecular forces.

January 2010

Base your answers to questions 58 through 60 on the information below.

The formula below represents a hydrocarbon.



58 Identify the homologous series to which this hydrocarbon belongs. [1]

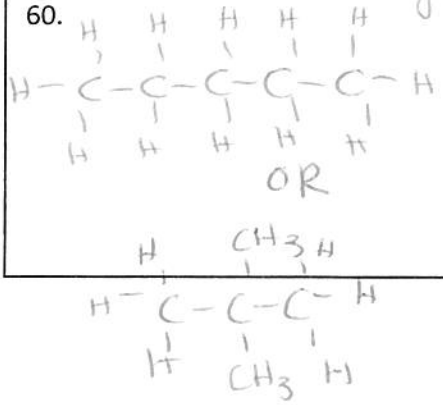
59 Explain, in terms of carbon-carbon bonds, why this hydrocarbon is saturated. [1]

60 In the space *in your answer booklet*, draw a structural formula for *one* isomer of this hydrocarbon. [1]

58. alkane

59. This is a saturated compound because all carbon-carbon bonds are single bonds.

60.



OR

August 2010

Base your answers to questions 67 through 69 on the information below.

Gasoline is a mixture composed primarily of hydrocarbons such as isooctane, which is also known as 2,2,4-trimethylpentane.

Gasoline is assigned a number called an octane rating. Gasoline with an octane rating of 87 performs the same as a mixture that consists of 87% isooctane and 13% heptane.

An alternative fuel, E-85, can be used in some automobiles. This fuel is a mixture of 85% ethanol and 15% gasoline.

67 State the octane rating of a gasoline sample that performs the same as a mixture consisting of 92% isooctane and 8% heptane. [1]

68 In the space *in your answer booklet*, draw a structural formula for a molecule of 2,2,4-trimethylpentane. [1]

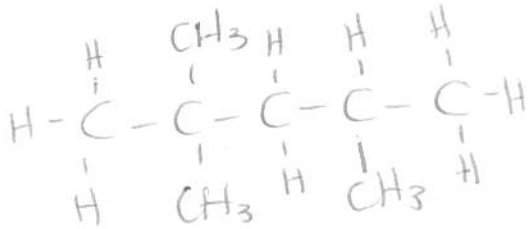
69 Identify the functional group in a molecule of ethanol in the alternative fuel E-85. [1]

**ANSWER SPACE FOR #67-69 ON NEXT PAGE →

ANSWERS:

67. 92 (*follow pattern in reading)

68.

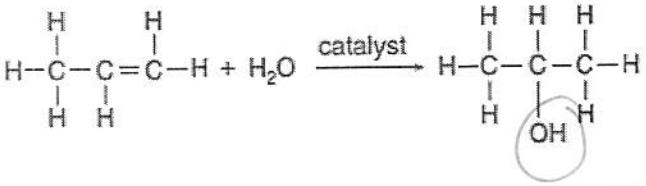


69. -OH

January 2011

Base your answers to questions 78 through 80 on the information below.

In one industrial organic reaction, C_3H_6 reacts with water in the presence of a catalyst. This reaction is represented by the balanced equation below.



78 Explain, in terms of bonding, why C_3H_6 is classified as an unsaturated hydrocarbon. [1]

79 Write the IUPAC name for the organic reactant. [1]

80 Identify the class of compound to which the product of the reaction belongs. [1]

ANSWERS:

78. one of the carbon-carbon bonds is a double bond which makes the compound unsaturated

79. propene or 1-propene

80. alcohol

CONSTRUCTED RESPONSE REVIEW: Nuclear Chemistry

June 2009

Base your answers to questions 68 through 70 on the information below.

Cobalt-60 is commonly used as a source of radiation for the prevention of food spoilage. Bombarding cobalt-59 nuclei with neutrons produces the nuclide cobalt-60. A food irradiation facility replaces the cobalt-60, a source of gamma rays, when the radioactivity level falls to $\frac{1}{8}$ of its initial level. The nuclide cesium-137 is also a source of radiation for the prevention of food spoilage.

68 Identify *one* emission spontaneously released by a cobalt-60 nucleus. [1]

69 Determine the total number of years that elapse before an original cobalt-60 source in an irradiation facility must be replaced. [1]

70 Complete the nuclear equation *in your answer booklet* for the decay of cesium-137. Your response must include the symbol, atomic number, and mass number of the missing particle. [1]

ANSWERS:

68. γ or β^-

69. 3(5.271 y) 15.813y

70 $^{137}_{55}Cs \rightarrow {}^{0}_{-1}e + {}^{137}_{56}Ba$

January 2010

52 Determine the total time that must elapse until only ¼ of an original sample of the radioisotope Rn-222 remains unchanged. [1]

$\frac{1}{2}\ \frac{1}{4}$ = 2 half lives 2(3.823 d)

Answer to Question 52

7.646 d.

Base your answers to questions 79 through 81 on the information below.

Hydrocarbons and fissionable nuclei are among the sources used for the production of energy in the United States. A chemical reaction produces much less energy than a nuclear reaction per mole of reactant.

The balanced chemical equation below represents the reaction of one molecule of a hydrocarbon with two molecules of oxygen.

Chemical equation: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + 1.48 \times 10^{-18}$ J ← heat released

The nuclear equation below represents one of the many possible reactions for one fissionable nucleus. In this equation, *X* represents a missing product.

Nuclear equation: ${}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{89}_{36}Kr + X + 3{}^{1}_{0}n + 3.36 \times 10^{-11}$ J

79 Identify the type of organic reaction represented by the chemical equation. [1]

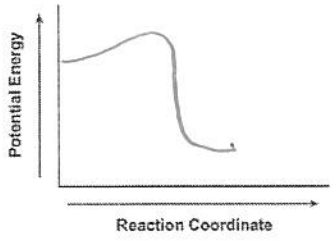
80 On the labeled axes *in your answer booklet*, draw a potential energy diagram for the reaction of the hydrocarbon with oxygen. [1]

81 Write an isotopic notation for the missing product represented by *X* in the nuclear equation. [1]

ANSWERS:

79. combustion

80.



81. $^{144}_{56}Ba$

August 2010

Base your answers to questions 79 through 81 on the information below.

The radioisotope uranium-238 occurs naturally in Earth's crust. The disintegration of this radioisotope is the first in a series of spontaneous decays.

The sixth decay in this series produces the radioisotope radon-222. The decay of radon-222 produces the radioisotope polonium-218 that has a half life of 3.04 minutes. Eventually, the stable isotope lead-206 is produced by the alpha decay of an unstable nuclide.

79 Explain, in terms of electron configuration, why atoms of the radioisotope produced by the sixth decay in the U-238 disintegration series do not readily react to form compounds. [1]

80 Complete the nuclear equation *in your answer booklet* for the decay of the unstable nuclide that produces Pb-206, by writing a notation for the missing nuclide. [1]

81 Determine the original mass of a sample of Po-218, if 0.50 milligram of the sample remains unchanged after 12.16 minutes. [1]

$\frac{12.16\text{ m}}{3.04\text{ m}} = 4$ half lives

$8 \rightarrow 4 \rightarrow 2 \rightarrow 1 \rightarrow .5$

ANSWERS:

79. stable valence shell (8 val. e⁻)

80 $^{210}_{84}Po \rightarrow {}^{4}_{2}He + {}^{206}_{82}Pb$

81. 8g

January 2011

Base your answers to questions 66 through 68 on the information below.

In the early 1800s, John Dalton proposed an atomic theory that was based on experimental observations made by several scientists. Three concepts of Dalton's atomic theory are stated below.

Statement *A*: Atoms are indivisible and cannot be destroyed or broken down into smaller parts.

Statement *B*: Atoms of one element cannot be changed into atoms of another element.

Statement *C*: All atoms of one element have the same mass.

66 Explain, in terms of particles, why statement *A* is no longer accepted. [1]

67 The decay of N-16 is represented by the balanced equation below.

$$^{16}_{7}N \rightarrow {}^{0}_{-1}e + {}^{16}_{8}O$$

State evidence that indicates statement *B* is *not* always true. [1]

68 Explain, in terms of particles in the atoms of an element, why statement *C* is *false*. [1]

Answers:

66. subatomic particles exist (p, n, e in atoms)

67. Nitrogen undergoes beta decay to become Oxygen.

68. All elements exist as isotopes - mass can differ due to different # n.