

1) Which of the quantities below has the largest mass?

- A) 2 mol of carbon
- B) 5 mol of hydrogen gas
- C) 6 mol of helium gas
- D) 2 mol of lithium metal
- E) 5 mol of aluminum metal

2) A molecule contains a central atom with two identical bonds to other atoms and two lone pairs. The shape of this molecule is \_\_\_\_\_.

- A) bent
- B) linear
- C) tetrahedral
- D) trigonal pyramidal
- E) trigonal planar

3) What is the molarity of a solution that contains 2.35 g of  $\text{NH}_3$  in 0.0500 L of solution?

- A) 2.76 M
- B) 47.0 M
- C) 0.276 M
- D) 27.6 M

4) The energy of an infrared photon is higher than that of \_\_\_\_\_.

- A) a microwave photon
- B) a gamma ray
- C) an ultraviolet photon
- D) a visible photon
- E) an X-ray photon

5) In a buffer system of HF and its salt, NaF,

- A) the  $\text{F}^-$  neutralizes added  $\text{H}_2\text{O}$ .
- B) the HF neutralizes added base.
- C) the HF neutralizes added acid.
- D) the HF is not necessary.
- E) the  $\text{F}^-$  neutralizes added base.

6) How many significant figures are there in the answer for the following problem?

$$\frac{[(131.7 - 119) \times 1.05]}{0.500} = ?$$

- A) one
- B) two
- C) three
- D) four

7) Which of the following is the basic unit of volume in the metric system?

- A) centimeter
- B) gallon
- C) kilogram
- D) liter

8) The name given to an aqueous solution of HBr is \_\_\_\_\_.

- A) hypobromous acid
- B) hydrogen bromide
- C) hydrobromic acid
- D) bromic acid
- E) bromous acid

9) Which of the following is the correct electron dot structure for  $\text{CS}_2$ ?

- A)  $\text{:}\ddot{\text{S}}=\ddot{\text{C}}=\ddot{\text{S}}\text{:}$
- B)  $\text{:}\ddot{\text{S}}-\ddot{\text{C}}-\ddot{\text{S}}\text{:}$
- C)  $\text{:}\ddot{\text{S}}-\ddot{\text{C}}=\text{C}-\ddot{\text{S}}\text{:}$
- D)  $\text{:}\ddot{\text{S}}=\text{C}=\ddot{\text{S}}\text{:}$

10) On a hot day, the thermometer read  $95^\circ\text{F}$ . What is the temperature in degrees Celsius?

- A)  $35^\circ\text{C}$
- B)  $178^\circ\text{C}$
- C)  $113^\circ\text{C}$
- D)  $77^\circ\text{C}$

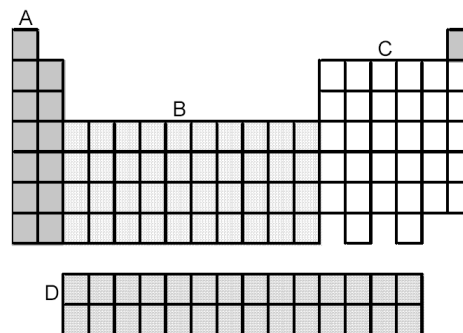
11) According to the United States Food and Drug Administration, the recommended daily requirement of protein is 44 g. This is \_\_\_\_\_ oz of protein. 1 ounce = 28.35 grams

- A) 0.0605
- B) 1248.5
- C) 150 000
- D) 1.6

12) Which one of the following substances will float in gasoline, which has a density (d) of 0.66 g/mL?

- A) mercury (d = 13.6 g/mL)
- B) balsa wood (d = 0.16 g/mL)
- C) sugar (d = 1.59 g/mL)
- D) aluminum (d = 2.70 g/mL)
- E) table salt (d = 2.16 g/mL)

- 13) Which of the following statements does not describe a **physical** property of chlorine?
- The color of chlorine gas is green.
  - Chlorine combines with sodium to form table salt.
  - The freezing point of chlorine is  $-101^{\circ}\text{C}$ .
  - The density of chlorine gas at standard temperature and pressure is  $3.17\text{ g/L}$ .
- 14) The half-life of a radioisotope is
- the time it takes for the radioisotope to become an isotope with one-half of the atomic weight of the original radioisotope.
  - the time it takes for the radioisotope to lose one-half of its neutrons.
  - the time it takes for one-half of the sample to decay to a new isotope.
  - the time it takes for the radioisotope to become an isotope with one-half the atomic number of the original radioisotope.
  - one-half of the time it takes for the radioisotope to completely decay to a nonradioactive isotope.
- 15) Significant figures are important because they indicate \_\_\_\_\_.
- the number of measurements
  - a counted number
  - the number of digits on a calculator
  - the accuracy of the conversion factor
  - the number of digits in a measurement
- 16) The Rutherford gold foil experiment demonstrated that atoms
- consist of an almost empty nucleus surrounded by a dense cloud of electrons.
  - are visible to the naked eye.
  - consist of a single type of subatomic particle.
  - are homogeneous.
  - consist of a dense nucleus surrounded by mostly empty space.



- 17) Which grouping of elements, indicated by letter on the periodic table above, represents the *f*-block elements?
- A
  - B
  - C
  - D
- 18) Which of the following measurements are NOT equivalent?
- $150\text{ msec} = 0.150\text{ sec}$
  - $84\text{ cm} = 8.4\text{ mm}$
  - $183\text{ L} = 0.183\text{ kL}$
  - $25\text{ mg} = 0.025\text{ g}$
  - $24\text{ dL} = 2.4\text{ L}$
- 19) The ionization energy of chlorine is lower than the ionization energy of \_\_\_\_\_.
- calcium
  - hydrogen
  - fluorine
  - lithium
- 20) The correct formula for copper (II) chloride is \_\_\_\_\_.
- $\text{Cu}_2\text{Cl}_4$
  - $\text{CuCl}_4$
  - $\text{Cu}_2\text{Cl}$
  - $\text{CuCl}_2$
- 21) Which of the following have the same number of valence electrons?
- N, P, As
  - Cs, Bi, At
  - In, Pb, Bi
  - Xe, Rn, At

22) Which products would result from the double replacement reaction between  $\text{MgCl}_2(aq)$  and  $\text{Na}_2\text{CO}_3(aq)$ ?

- A)  $\text{NaCl}(aq)$  and  $\text{Mg}(\text{CO}_3)_2(s)$
- B)  $\text{NaCl}(aq)$  and  $\text{MgCO}_3(s)$
- C)  $\text{Na}_2\text{Cl}_2(aq)$  and  $\text{MgCO}_3(s)$
- D)  $\text{NaCl}(aq)$  and  $\text{Mg}_2\text{CO}_3(s)$
- E)  $\text{MgNa}_2(aq)$  and  $\text{CO}_3\text{Cl}_2(aq)$

23) Calcium chloride reacts with sodium hydroxide to form solid calcium hydroxide,  $\text{Ca}(\text{OH})_2$ . The balanced net ionic equation is

- A)  $\text{CaCl}_2(aq) + 2\text{NaOH}(aq) \rightarrow \text{Ca}(\text{OH})_2(s) + 2\text{NaCl}(aq)$
- B)  $\text{Ca}^{+2}(aq) + 2\text{OH}^-(aq) + 2\text{Na}^+(aq) + 2\text{Cl}^-(aq) \rightarrow \text{Ca}(\text{OH})_2(s)$
- C)  $\text{Ca}^{+2}(aq) + 2\text{OH}^-(aq) \rightarrow \text{Ca}(\text{OH})_2(s)$
- D)  $\text{CaCl}_2(aq) + 2\text{NaOH}(aq) \rightarrow \text{CaOH}(s) + \text{NaCl}(aq)$

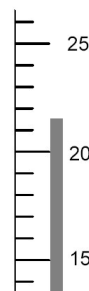
24) For any chemical reaction to occur the reactants must

- A) be at the same concentration.
- B) bounce off the walls of the container.
- C) collide with sufficient energy to break bonds.
- D) be present in stoichiometric quantities.
- E) be of the same chemical type.

25) Which of the following is an example of potential energy?

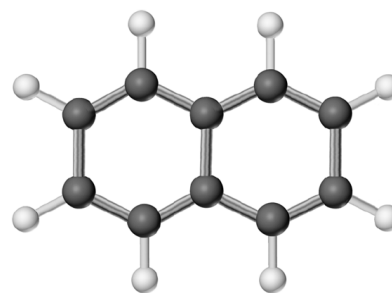
- A) water stored in a reservoir
- B) riding an exercise bike
- C) burning wood
- D) a fan blade turning
- E) chewing food

26) To the correct number of significant figures, what is the temperature reading on the following Celsius thermometer?



- A)  $21^\circ\text{C}$
- B)  $22^\circ\text{C}$
- C)  $21.70^\circ\text{C}$
- D)  $21.7^\circ\text{C}$

27) Give the molecular formula corresponding to the following ball-and-stick molecular representation of naphthalene (gray = C, unshaded = H). In writing the formula, list the atoms in alphabetical order.



- A)  $\text{C}_{10}\text{H}_{10}$
- B)  $\text{C}_5\text{H}_4$
- C)  $\text{C}_{10}\text{H}_8$
- D) CH

28) A solution with a pH of 4 is

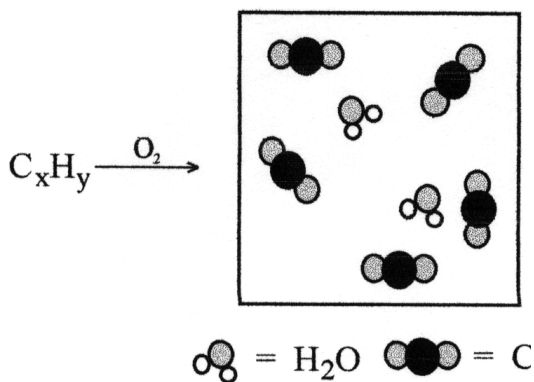
- A) moderately acidic.
- B) neutral.
- C) extremely acidic.
- D) slightly basic.
- E) extremely basic.

- 29) Atomic emission spectra are due to electrons
- being removed from an atom.
  - changing state from solid to liquid.
  - in an atom dropping from one energy level to a lower one.
  - being added to an atom.
  - in an atom rising from one energy level to a higher one.
- 30) Which one of the following compounds contains the **smallest** percent oxygen by mass?
- N<sub>2</sub>O<sub>4</sub>
  - CO<sub>2</sub>
  - SO<sub>2</sub>
  - P<sub>4</sub>O<sub>10</sub>
- 31) Raising the temperature of 10.0 g of water from 10.0°C to 20.0°C requires 418 J, while raising the temperature of 10.0 g of aluminum from 10.0°C to 20.0°C requires 89.7 J. More joules are required to heat the water because
- water is a liquid and aluminum is a solid at 10.0°C.
  - 10.0°C is closer to the melting point of water than to the melting point of aluminum.
  - water has a greater potential energy than aluminum.
  - water has a larger specific heat than aluminum.
  - ten grams of water occupies a larger volume than 10.0 g of aluminum.
- 32) Which of the following correctly gives the best coefficients for the reaction below?
- $$\text{N}_2\text{H}_4 + \text{H}_2\text{O}_2 \rightarrow \text{N}_2 + \text{H}_2\text{O}$$
- 2, 4, 2, 8
  - 1, 2, 1, 4
  - 1, 1, 1, 1
  - 2, 4, 2, 4
- 33) Which of the following substances contains a nonpolar bond?
- NH<sub>3</sub>
  - N<sub>2</sub>
  - NaCl
  - H<sub>2</sub>O
- 34) What is the correct form for the equilibrium constant for this reaction?
- $$\text{H}_2(\text{g}) + \text{F}_2(\text{g}) \rightleftharpoons 2 \text{HF}(\text{g})$$
- $\frac{[\text{HF}]^2}{[\text{H}_2][\text{F}_2]}$
  - $\frac{[\text{H}_2][\text{F}_2]}{[\text{HF}]}$
  - $\frac{[\text{H}_2][\text{F}_2]}{[\text{HF}]^2}$
  - $\frac{[\text{HF}]}{[\text{H}_2][\text{F}_2]}$
- 35) Which of the following is NOT true for the atoms <sup>13</sup>N, <sup>14</sup>N, and <sup>15</sup>N?
- They all have the same mass number.
  - They all have 7 protons.
  - They all have the same atomic number.
  - They are isotopes.
  - They all have 7 electrons.
- 36) In water, the melting point is unusually high because of
- dispersion forces between the molecules.
  - ionic bonds in the individual molecules.
  - covalent bonds in the individual molecules.
  - the heat content of the hydrogen–oxygen bonds.
  - hydrogen bonding between the molecules.
- 37) Acetylene torches utilize the following reaction:
- $$2 \text{C}_2\text{H}_2(\text{g}) + 5 \text{O}_2(\text{g}) \rightarrow 4 \text{CO}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{g})$$
- Use the given standard enthalpies of formation to calculate  $\Delta H^\circ$  for this reaction
- | Species                           | $\Delta H^\circ_f$ , kJ/mol |
|-----------------------------------|-----------------------------|
| C <sub>2</sub> H <sub>2</sub> (g) | +226.7                      |
| CO <sub>2</sub> (g)               | -393.5                      |
| H <sub>2</sub> O(g)               | -241.6                      |
- 408.6 kJ
  - 2511. kJ
  2511. kJ
  - 408.6 kJ

38) The equilibrium constant for the production of carbon dioxide from carbon monoxide and oxygen is  $K_C = 2 \times 10^{11}$ . This means that the reaction mixture at equilibrium is likely to consist of

- A) mostly products.
- B) an equal mixture of products and reactants.
- C) twice as much product as starting material.
- D) mostly starting materials.
- E) twice as much starting material as product.

39) A hydrocarbon of unknown formula  $C_xH_y$  was submitted to combustion analysis with the following results. What is the empirical formula of the hydrocarbon?

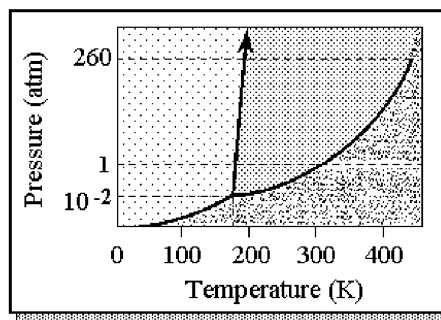


- A)  $C_{10}H_8$
- B)  $C_5H_4$
- C)  $C_5H_2$
- D)  $C_{10}H_4$

40) In this set of chemical reactions, which reaction is an oxidation-reduction reaction?

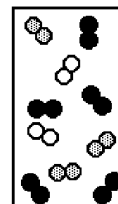
- A)  $K_2SO_4 + BaCl_2 \rightarrow BaSO_4 + 2KCl$
- B)  $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$
- C)  $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$
- D)  $Pb(NO_3)_2 + 2NaCl \rightarrow PbCl_2 + 2NaNO_3$
- E)  $CuSO_4 + BaCl_2 \rightarrow BaSO_4 + CuCl_2$

The phase diagram of a substance is shown below.



- 41) What is the physical phase of the substance at  $T = 400\text{ K}$  and  $P = 2.0\text{ atm}$ ?
- A) gas
  - B) solid
  - C) liquid
  - D) supercritical fluid

In the diagram below, nitrogen molecules are represented by unshaded spheres, oxygen molecules by gray spheres, and chlorine molecules by black spheres.



- 42) If the total pressure in the container is 900 mm Hg, what is the partial pressure of nitrogen?
- A) 450 mm Hg
  - B) 180 mm Hg
  - C) 270 mm Hg
  - D) 90 mm Hg

43) A diver exhales a bubble with a volume of 250. mL at a pressure of 2.42 atm and a temperature of  $15.^{\circ}\text{C}$ . What is the volume of the bubble when it reaches the surface where the pressure is 1.00 atm and the temperature is  $27.^{\circ}\text{C}$ ?

- A) 630. mL
- B) 1 100 mL
- C) 110. mL
- D) 580. mL



- 53) According to the kinetic theory of gases, a gas can be compressed much more than a liquid or solid because

A) the particles of a gas are very far apart.  
 B) gas particles do not attract or repel one another.  
 C) gas particles move rapidly.  
 D) a gas is composed of very small particles.  
 E) gas particles move faster when the temperature increases.

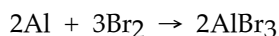
- 54) A piece of metal with a mass of 521 g is added to 50.0 mL of water. The water level rises to a volume of 77.0 mL. What is the density of the gold?

A) 6.77 g/mL                      B) 19.3 g/mL  
 C) 10.4 g/mL                      D) 0.0518 g/mL

- 55) The  $K_a$  for hydrofluoric acid is  $7.2 \times 10^{-4}$ . This means that HF is

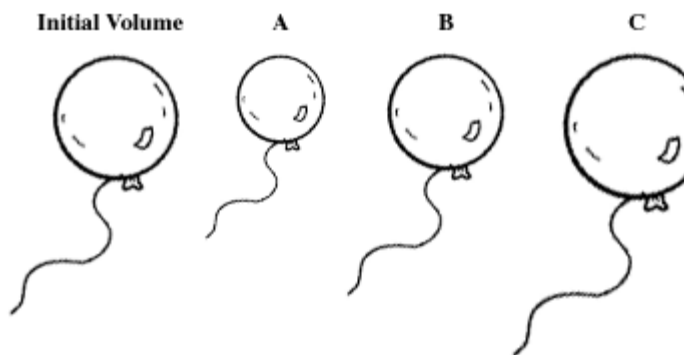
A) a strong acid.  
 B) able to react with HCl.  
 C) neutral in water solution.  
 D) ionic.  
 E) a weak acid.

- 56) What is oxidized and what is reduced in the following reaction?



A)  $\text{AlBr}_3$  is reduced and Al is oxidized.  
 B) Al is oxidized and  $\text{Br}_2$  is reduced.  
 C) Al is reduced and  $\text{Br}_2$  is oxidized.  
 D)  $\text{AlBr}_3$  is oxidized and Al is reduced.  
 E)  $\text{AlBr}_3$  is reduced and  $\text{Br}_2$  is oxidized.

**A balloon is filled with helium gas. For the following questions, select the letter of the balloon diagram that corresponds to the given change in conditions.**



- 57) The temperature is changed from  $50.^\circ\text{C}$  to  $-150^\circ\text{C}$  at constant pressure.

A) Balloon A  
 B) Balloon B  
 C) Balloon C  
 D) Balloons B and C  
 E) Balloons A and B

- 58) What is the electron arrangement for aluminum?

A)  $1s^2 2s^2 2p^6 3s^2 3p^3$   
 B)  $1s^2 2s^2 2p^6 3s^2 3p^8$   
 C)  $1s^2 2s^2 2p^6 3s^2 3p^6$   
 D)  $1s^2 2s^2 2p^6 3s^2 3p^5$   
 E)  $1s^2 2s^2 2p^6 3s^2 3p^1$

- 59) The Group 8A(18) elements

A) are good conductors of electricity.  
 B) melt at high temperatures.  
 C) react vigorously with water.  
 D) are liquids at room temperature.  
 E) are unreactive.

- 60) What is the expected freezing point of a 0.50 m solution of  $\text{Na}_2\text{SO}_4$  in water?  $K_f$  for water is  $1.86^\circ\text{C}/m$ .

A)  $-2.8^\circ\text{C}$                       B)  $-1.9^\circ\text{C}$   
 C)  $-0.93^\circ\text{C}$                       D)  $-6.5^\circ\text{C}$

## Answer Key

Testname: 2007 OLYMPIAD.FIRST YEAR

- |       |       |
|-------|-------|
| 1) E  | 51) A |
| 2) A  | 52) D |
| 3) A  | 53) A |
| 4) A  | 54) B |
| 5) B  | 55) E |
| 6) B  | 56) B |
| 7) D  | 57) A |
| 8) C  | 58) E |
| 9) D  | 59) E |
| 10) A | 60) A |
| 11) D |       |
| 12) B |       |
| 13) B |       |
| 14) C |       |
| 15) E |       |
| 16) E |       |
| 17) D |       |
| 18) B |       |
| 19) C |       |
| 20) D |       |
| 21) A |       |
| 22) B |       |
| 23) C |       |
| 24) C |       |
| 25) A |       |
| 26) D |       |
| 27) C |       |
| 28) A |       |
| 29) C |       |
| 30) C |       |
| 31) D |       |
| 32) B |       |
| 33) B |       |
| 34) A |       |
| 35) A |       |
| 36) E |       |
| 37) B |       |
| 38) A |       |
| 39) B |       |
| 40) B |       |
| 41) A |       |
| 42) B |       |
| 43) A |       |
| 44) B |       |
| 45) D |       |
| 46) D |       |
| 47) A |       |
| 48) D |       |
| 49) C |       |
| 50) C |       |