Sample Multiple-Choice Questions

The following multiple-choice questions provide a representative subset of those used in previous AP Chemistry Exams. There are two types of multiple-choice questions. The first type consists of five lettered headings followed by a list of numbered phrases. For each numbered phrase, the student is instructed to select the one heading that is most closely related to it. Each heading may be used once, more than once, or not at all in each group.

Questions 1–3 refer to atoms of the following elements.

   (A) Lithium
   (B) Carbon
   (C) Nitrogen
   (D) Oxygen
   (E) Fluorine

1. In the ground state, have only 1 electron in each of the three p orbitals

2. Have the smallest atomic radius

3. Have the smallest value for first ionization energy

The majority of the multiple-choice questions consist of questions or incomplete statements followed by five suggested answers or completions. The student is instructed to select the one that is best in each case.

4. Which of the following species is NOT planar?

   (A) CO_3^{2-}
   (B) NO_3^-
   (C) ClF_3
   (D) BF_3
   (E) PCl_3

$$H-\overset{\overset{\displaystyle H}{|}}{C}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-H$$
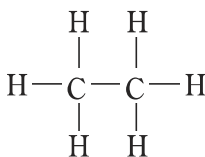
5. The hybridization of the carbon atoms in the molecule represented above can be described as

   (A) sp
   (B) sp^2
   (C) sp^3
   (D) dsp^2
   (E) d^2sp

6. The half-life of ^{55}Cr is about 2.0 hours. The delivery of a sample of this isotope from the reactor to a certain laboratory requires 12 hours. About what mass of such material should be shipped in order that 1.0 mg of ^{55}Cr is delivered to the laboratory?

   (A) 130 mg
   (B) 64 mg
   (C) 32 mg
   (D) 11 mg
   (E)   1.0 mg

7. At constant temperature, the behavior of a sample of a real gas more closely approximates that of an ideal gas as its volume is increased because the

   (A) collisions with the walls of the container become less frequent
   (B) average molecular speed decreases
   (C) molecules have expanded
   (D) average distance between molecules becomes greater
   (E) average molecular kinetic energy decreases

8. A sealed vessel contains 0.200 mol of oxygen gas, 0.100 mol of nitrogen gas, and 0.200 mol of argon gas. The total pressure of the gas mixture is 5.00 atm. The partial pressure of the argon is

   (A) 0.200 atm
   (B) 0.500 atm
   (C) 1.00 atm
   (D) 2.00 atm
   (E) 5.00 atm

9. Which of the following accounts for the fact that liquid CO_2 is <u>not</u> observed when a piece of solid CO_2 (dry ice) is placed on a lab bench?

   (A) The phase diagram for CO_2 has no triple point.
   (B) The normal boiling point of CO_2 is lower than its normal freezing point.
   (C) $CO_2(s)$ is a molecular solid.
   (D) The critical pressure for CO_2 is approximately 1 atm.
   (E) The triple point for CO_2 is above 1 atm.

10. If ΔG for a certain reaction has a negative value at 298 K, which of the following must be true?

    I. The reaction is exothermic.
    II. The reaction occurs spontaneously at 298 K.
    III. The rate of the reaction is fast at 298 K.

    (A) I only
    (B) II only
    (C) I and II only
    (D) II and III only
    (E) I, II, and III

$$2 \, SO_2(g) + O_2(g) \rightarrow 2 \, SO_3(g)$$
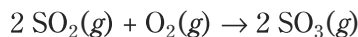
11. A mixture of gases containing 0.20 mol of SO_2 and 0.20 mol of O_2 in a 4.0 L flask reacts to form SO_3. If the temperature is 25°C, what is the pressure in the flask after reaction is complete?

(A) $\dfrac{0.4(0.082)(298)}{4}$ atm

(B) $\dfrac{0.3(0.082)(298)}{4}$ atm
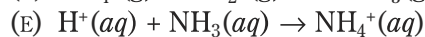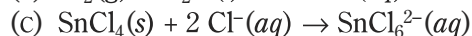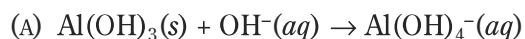
(C) $\dfrac{0.2(0.082)(298)}{4}$ atm

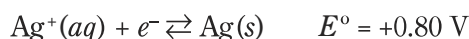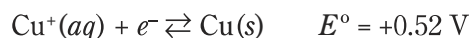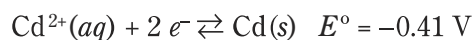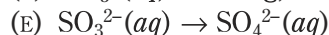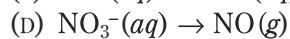(D) $\dfrac{0.2(0.082)(25)}{4}$ atm

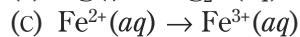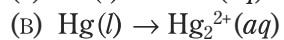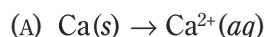(E) $\dfrac{0.3(0.082)(25)}{4}$ atm

12. A solution prepared by mixing 10 mL of 1 M HCl and 10 mL of 1.2 M NaOH has a pH of

(A) 0   (B) 1   (C) 7   (D) 13   (E) 14

13. All of the following reactions can be defined as Lewis acid-base reactions EXCEPT

(A) $Al(OH)_3(s) + OH^-(aq) \rightarrow Al(OH)_4^-(aq)$
(B) $Cl_2(g) + H_2O(l) \rightarrow HOCl(aq) + H^+(aq) + Cl^-(aq)$
(C) $SnCl_4(s) + 2 \, Cl^-(aq) \rightarrow SnCl_6^{2-}(aq)$
(D) $NH_4^+(g) + NH_2^-(g) \rightarrow 2 \, NH_3(g)$
(E) $H^+(aq) + NH_3(aq) \rightarrow NH_4^+(aq)$

14. Which of the following represents a process in which a species is reduced?

(A) $Ca(s) \rightarrow Ca^{2+}(aq)$
(B) $Hg(l) \rightarrow Hg_2^{2+}(aq)$
(C) $Fe^{2+}(aq) \rightarrow Fe^{3+}(aq)$
(D) $NO_3^-(aq) \rightarrow NO(g)$
(E) $SO_3^{2-}(aq) \rightarrow SO_4^{2-}(aq)$

$$Cd^{2+}(aq) + 2 \, e^- \rightleftarrows Cd(s) \quad E° = -0.41 \, V$$
$$Cu^+(aq) + e^- \rightleftarrows Cu(s) \quad E° = +0.52 \, V$$
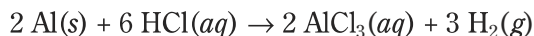$$Ag^+(aq) + e^- \rightleftarrows Ag(s) \quad E° = +0.80 \, V$$

15. Based on the standard electrode potentials given above, which of the following is the strongest reducing agent?

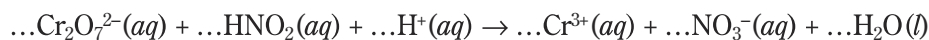(A) $Cd(s)$ (B) $Cd^{2+}(aq)$ (C) $Cu(s)$ (D) $Ag(s)$ (E) $Ag^+(aq)$

16. A sample of $CaCO_3$ (molar mass 100. g) was reported as being 30. percent Ca. Assuming no calcium was present in any impurities, the percent of $CaCO_3$ in the sample is

    (A) 30%   (B) 40%   (C) 70%   (D) 75%   (E) 100%

$$2\ Al(s) + 6\ HCl(aq) \rightarrow 2\ AlCl_3(aq) + 3\ H_2(g)$$

17. According to the reaction represented above, about how many grams of aluminum (atomic mass 27 g) are necessary to produce 0.50 mol of hydrogen gas at 25°C and 1.00 atm?

    (A) 1.0 g
    (B) 9.0 g
    (C) 14 g
    (D) 27 g
    (E) 56 g

$$\ldots Cr_2O_7^{2-}(aq) + \ldots HNO_2(aq) + \ldots H^+(aq) \rightarrow \ldots Cr^{3+}(aq) + \ldots NO_3^-(aq) + \ldots H_2O(l)$$

18. When the equation for the redox reaction represented above is balanced and all coefficients are reduced to lowest whole-number terms, the coefficient for $H_2O(l)$ is

    (A) 3   (B) 4   (C) 5   (D) 6   (E) 8

19. Which of the following equations represents the net reaction that occurs when gaseous hydrofluoric acid reacts with solid silicon dioxide?

    (A) $2\ H^+(aq) + 2\ F^-(aq) + SiO_2(s) \rightarrow SiOF_2(s) + H_2O(l)$
    (B) $4\ F^-(aq) + SiO_2(s) \rightarrow SiF_4(g) + 2\ O^{2-}(aq)$
    (C) $4\ HF(g) + SiO_2(s) \rightarrow SiF_4(g) + 2\ H_2O(l)$
    (D) $4\ HF(g) + SiO_2(s) \rightarrow Si(s) + 2\ F_2(g) + 2\ H_2O(l)$
    (E) $2\ H_2F(g) + Si_2O_2(s) \rightarrow 2\ SiF(g) + 2\ H_2O(l)$

20. The ionization constant for acetic acid is 1.8×10^{-5}; that for hydrocyanic acid is 4×10^{-10}. In 0.1 M solutions of sodium acetate and sodium cyanide, it is true that

    (A) $[H^+]$ equals $[OH^-]$ in each solution
    (B) $[H^+]$ exceeds $[OH^-]$ in each solution
    (C) $[H^+]$ of the sodium acetate solution is less than that of the sodium cyanide solution
    (D) $[OH^-]$ of the sodium acetate solution is less than that of the sodium cyanide solution
    (E) $[OH^-]$ for the two solutions is the same

$$HCl > HC_2H_3O_2 > HCN > H_2O > NH_3$$

21. Five acids are listed above in the order of decreasing acid strength. Which of the following reactions must have an equilibrium constant with a value less than 1?

(A) $HCl(aq) + CN^-(aq) \rightleftarrows HCN(aq) + Cl^-(aq)$
(B) $HCl(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + Cl^-(aq)$
(C) $HC_2H_3O_2(aq) + OH^-(aq) \rightleftarrows C_2H_3O_2^-(aq) + H_2O(l)$
(D) $H_2O(aq) + NH_2^-(aq) \rightleftarrows NH_3(aq) + OH^-(aq)$
(E) $HCN(aq) + C_2H_3O_2^-(aq) \rightleftarrows HC_2H_3O_2(aq) + CN^-(aq)$

Experiment	Initial [X] (mol L^{-1})	Initial [Y] (mol L^{-1})	Initial Rate of Formulation of Z (mol L^{-1} min^{-1})
1	0.10	0.30	4.0×10^{-4}
2	0.20	0.60	1.6×10^{-3}
3	0.20	0.30	4.0×10^{-4}

22. The data in the table above were obtained for the reaction $X + Y \rightarrow Z$. Which of the following is the rate law for the reaction?

(A) Rate = $k[X]^2$
(B) Rate = $k[Y]^2$
(C) Rate = $k[X][Y]$
(D) Rate = $k[X]^2[Y]$
(E) Rate = $k[X][Y]^2$

$$A \rightarrow X$$

23. The enthalpy change for the reaction represented above is ΔH_T. This reaction can be broken down into a series of steps as shown in the diagram:
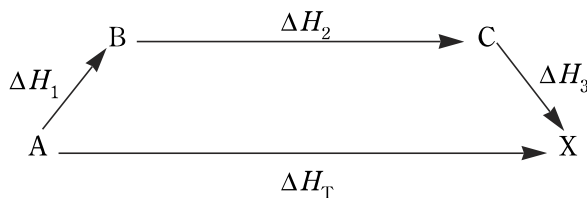
A relationship that must exist among the various enthalpy changes is

(A) $\Delta H_T - \Delta H_1 - \Delta H_2 - \Delta H_3 = 0$
(B) $\Delta H_T + \Delta H_1 + \Delta H_2 + \Delta H_3 = 0$
(C) $\Delta H_3 - (\Delta H_1 + \Delta H_2) = \Delta H_T$
(D) $\Delta H_2 - (\Delta H_3 + \Delta H_1) = \Delta H_T$
(E) $\Delta H_T + \Delta H_2 = \Delta H_1 + \Delta H_3$

24. What formula would be expected for a binary compound of barium and nitrogen?

(A) Ba_3N_2 (B) Ba_2N_3 (C) Ba_2N (D) BaN_2 (E) BaN

25. All of the following statements about the nitrogen family of elements are true EXCEPT:

    (A) It contains both metals and nonmetals.
    (B) The electronic configuration of the valence shell of the atom is ns^2np^3.
    (C) The only oxidation states exhibited by members of this family are –3, 0, +3, +5.
    (D) The atomic radii increase with increasing atomic number.
    (E) The boiling points increase with increasing atomic number.

26. Of the following organic compounds, which is LEAST soluble in water at 298 K?

    (A) CH_3OH, methanol
    (B) $CH_3CH_2CH_2OH$, l-propanol
    (C) C_6H_{14}, hexane
    (D) $C_6H_{12}O_6$, glucose
    (E) CH_3COOH, ethanoic (acetic) acid

27. Which of the following salts forms a basic solution when dissolved in water?

    (A) $NaCl$
    (B) $(NH_4)_2SO_4$
    (C) $CuSO_4$
    (D) K_2CO_3
    (E) NH_4NO_3

28. The molecular mass of a substance can be determined by measuring which of the following?

    I.   Osmotic pressure of a solution of the substance
    II. Freezing point depression of a solution of the substance
    III. Density of the gas (vapor) phase of the substance

    (A) I only
    (B) III only
    (C) I and II only
    (D) II and III only
    (E) I, II, and III

29. The table below summarizes the reactions of a certain unknown solution when treated with bases.

		Results	
Sample	Reagent	Limited Amount of Reagent	Excess Reagent
I	NaOH (*aq*)	White precipitate	Precipitate dissolves
II	NH_3(*aq*)	White precipitate	White precipitate

Which of the following metallic ions could be present in the unknown solution?

(A) Ca^{2+} (*aq*)
(B) Zn^{2+} (*aq*)
(C) Ni^{2+} (*aq*)
(D) Al^{3+} (*aq*)
(E) Ag^+ (*aq*)

Answers to Multiple-Choice Questions

1 – C	7 – D	13 – B	19 – C	25 – C
2 – E	8 – D	14 – D	20 – D	26 – C
3 – A	9 – E	15 – A	21 – E	27 – D
4 – E	10 – B	16 – D	22 – B	28 – E
5 – C	11 – B	17 – B	23 – A	29 – D
6 – B	12 – D	18 – B	24 – A	