16 Math-MCQ

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1. When hafnium metal is heated in an atmosphere of chlorine gas, the product of the reaction is found to contain 62.2 percent Hf by mass and 37.4 percent Cl by mass. What is the empirical formula for this compound?

178.49 35.45

$\frac{37.4\text{ g}}{35.45\text{ g/mol}} = 1.055\text{ mol}$

$\frac{62.29\text{ g}}{178.49\text{ g/mol}} = 0.348$

1 3

(A) $HfCl$

(B) $HfCl_2$

(C) $HfCl_3$

(D) $HfCl_4$

(E) Hf_2Cl_3

2. When 70. milliliter of 3.0-molar Na_2CO_3 is added to 30. milliliters of 1.0-molar $NaHCO_3$ the resulting concentration of Na^+ is

0.1 L

(A) 2.0 M

(B) 2.4 M

(C) 4.0 M

$0.07\text{ L} \left|\frac{3\text{ mol}}{1\text{ L}}\right|\left|\frac{2\text{ mol Na}}{1\text{ mol}}\right| = 0.42\text{ mol Na}$

(D) 4.5 M

(E) 7.0 M

0.45

$0.03\text{ L} \left|\frac{1\text{ mol}}{1\text{ L}}\right|\left|\frac{1\text{ mol}}{1\text{ mol}}\right| = 0.03$

Refer to three gases in identical rigid containers under the conditions given in the table below.

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Container	A	B	C
Gas	Methane	Ethane	Butane
Formula	CH_4	C_2H_6	C_4H_{10}
Molar mass (g/mol)	16	30.	58
Temperature (°C)	27	27	27
Pressure (atm)	2.0	4.0	2.0

3. The density of the gas, in g/L, is

PV=nRT

(A) greatest in container A

(B) greatest in container B

(C) greatest in container C

(D) the same in all three containers

4. $5\ Fe^{2+} + MnO_4^- + 8\ H^+ \rightleftarrows 5\ Fe^{3+} + Mn^{2+} + 4\ H_2O$

In a titration experiment based on the equation above, 25.0 milliliters of an acidified Fe^{2+} solution requires 14.0 milliliters of standard 0.050–molar MnO_4^- solution to reach the equivalence point. The concentration of Fe^{2+} in the original solution is

$$\frac{0.014\ L \mid 0.05\ mol \mid 5\ mol\ Fe}{L \mid \quad \mid 1\ mol} = 0.0035$$

(A) 0.0010 *M*

(B) 0.0056 *M*

(C) 0.0028 *M*

$$\frac{0.0035}{0.025}$$

(D) 0.0090 *M*

(E) 0.14 *M*

5. The isomerization of cyclopropane to propylene is a first-order process with a half-life of 19 minutes at 500°C. The time it takes for the partial pressure of cyclopropane to decrease from 1.0 atmosphere to 0.125 atmosphere at 500°C is closest to

(A) 38 minutes

(B) 57 minutes

(C) 76 minutes

(D) 152 minutes

(E) 190 minutes

6.

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}

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

(A) Rate = $k[X]^2$

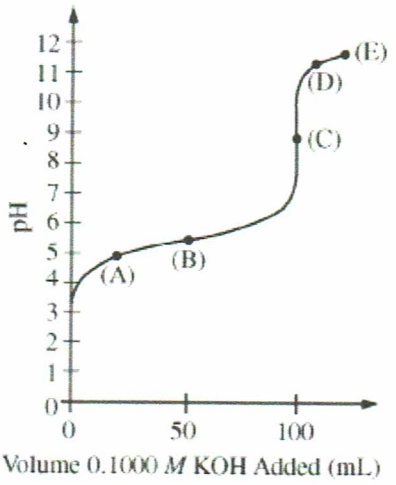
(B) Rate = $k[Y]^2$

(C) Rate = $k[X][Y]$

(D) Rate = $k[X]^2[Y]$

(E) Rate = $k[X][Y]^2$

7. A solution of a weak monoprotic acid is titrated with a solution of a strong base, KOH. Consider the points labeled (A) through (E) on the titration curve that results, as shown below.



The point at which the concentrations of the weak acid and its conjugate base are approximately equal

(A) A

(B) B

(C) C

(D) D

(E) E

8. The net ionic equation for the reaction that occurs during the titration of nitrous acid with sodium hydroxide is

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(A) $HNO_2 + Na^+ + OH^- \rightarrow NaNO_2 + H_2O$

(B) $HNO_2 + NaOH \rightarrow Na^+ + NO_2^- + H_2O$

(C) $H^+ + OH^- \rightarrow H_2O$

(D) $HNO_2 + H_2O \rightarrow NO_2^- + H_3O^+$

(E) $HNO_2 + OH^- \rightarrow NO_2^- + H_2O$

$HNO_2 + NaOH \rightarrow NaNO_2 + H_2O$

9. What is the $H^+(aq)$ concentration in 0.05 M HCN(aq) ? (The K_a for HCN is 5.0×10^{-10}.)

(A) $2.5 \times 10^{-11} M$

(B) $2.5 \times 10^{-10} M$

(C) $5.0 \times 10^{-10} M$

(D) $5.0 \times 10^{-6} M$

(E) $5.0 \times 10^{-4} M$

	$HCN \rightleftharpoons$	H^+	$+ CN^-$
I	0.05	0	0
C	$-x$	x	x
E	$0.05 - x$	x	x

$$\frac{x^2}{0.05 - x} = 5 \cdot 10^{-10}$$

0.000005

10. $Cu(s) + 2\ Ag^+ \rightarrow Cu^{2+} + 2\ Ag(s)$

If the equilibrium constant for the reaction above is 3.7×10^{15}, which of the following correctly describes the standard voltage, E°, and the standard free energy change, ΔG°, for this reaction?

(A) E° is positive and ΔG° is negative.

(B) E° is negative and ΔG° is positive.

(C) E° and ΔG° are both positive.

(D) E° and ΔG° are both negative.

(E) E° and ΔG° are both zero.

Reaction 1: $CaC_2(s) + 2\ H_2O(l) \rightarrow C_2H_2(g) + Ca(OH)_2(s)$

Reaction 2: $NaOCl(aq) + 2\ HCl(aq) \rightarrow Cl_2(g) + NaCl(aq) + H_2O(l)$

Reaction 3: $C_2H_2(g) + Cl_2(g) \rightarrow C_2H_2Cl_2(g)$

11. $Ca(OH)_2(s)$ precipitates when a 1.0 g sample of $CaC_2(s)$ is added to 1.0 L of distilled water at room temperature. If a 0.064 g sample of $CaC_2(s)$ (molar mass 64 g/mol) is used instead and all of it reacts, which of the following will occur and why? (The value of K_{sp} for $Ca(OH)_2$ is 8.0×10^{-8}.)

(A) $Ca(OH)_2$ will precipitate because $Q > K_{sp}$.

(B) $Ca(OH)_2$ will precipitate because $Q < K_{sp}$.

(C) $Ca(OH)_2$ will not precipitate because $Q > K_{sp}$.

(D) $Ca(OH)_2$ will not precipitate because $Q < K_{sp}$.

12.

$$X(g) + 2\,Q(g) \rightleftarrows R(g) + Z(g) \quad K_c = 1.3 \times 10^5 \text{ at } 50°C$$

A 1.0 mol sample of $X(g)$ and a 1.0 mol sample of $Q(g)$ are introduced into an evacuated, rigid 10.0 L container and allowed to reach equilibrium at 50°C according to the equation above. At equilibrium, which of the following is true about the concentrations of the gases?

$$\frac{[R][Z]}{[X][Q]^2}$$

(A) [R] = 1/2[Q]

(B) [Q] = 1/2[X]

(C) [R] = [Z] > [Q]

(D) [x] = [Q] = [R] = [Z]

13.

$H_2CO_3(aq) + H_2O(l) \rightleftarrows HCO_3^-(aq) + H_3O^+(aq)$	K_1
$HCO_3^-(aq) + H_2O(l) \rightleftarrows CO_3^{2-}(aq) + H_3O^+(aq)$	K_2
$NH_3(aq) + H_2O(l) \rightleftarrows NH_4^+(aq) + OH^-(aq)$	K_3
$2\,H_2O(l) \rightleftarrows H_3O^+(aq) + OH^-(aq)$	K_4

$H_2CO_3(aq) + NH_3(aq) \rightleftarrows NH_4^+(aq) + HCO_3^-(aq)$ $K_5 = ?$

The table above lists some equilibrium systems and their equilibrium constants. Which of the following identifies the correct mathematical relationship that uses the information to calculate K_5?

$$\frac{[NH_4][HCO_3^-]}{[H_2CO_3][NH_3]} \quad K_1 \cdot K_3 \quad (K_4)$$

(A) $K_5 = \frac{K_1 \times K_3}{K_4}$

(B) $K_5 = \frac{K_4}{K_1 \times K_3}$

(C) $K_5 = K_1 \times K_3 \times K_4$

(D) $K_5 = \frac{K_1 \times K_3}{K_2}$

The following questions refer to the graph below, which shows the heating curve for methane, CH_4.

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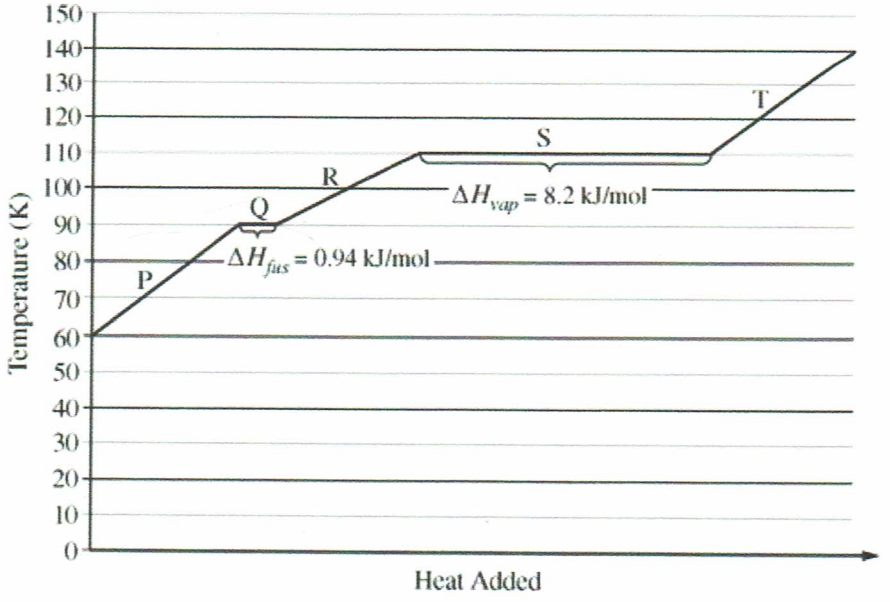

14. How much energy is required to melt 64 g of methane at 90 K? (The molar mass of methane is 16 g/mol.)

(A) 0.24 kJ

9 mol

(B) 3.8 kJ

(C) 33 kJ

(D) 60. kJ

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15.

Bond Type	Average Bond Enthalpy $\left(\frac{\text{kJ}}{\text{mol}}\right)$
C – C	360
C = O	799
C ≡ O	1072
O – O	142
O = O	498

The oxidation of carbon monoxide can be represented by the chemical equation $2\,CO(g) + O_2(g) \rightarrow 2\,CO_2(g)$. The table above provides the average bond enthalpies for different bond types. Based on the information in the table, which of the following mathematical expressions is correct for the estimated enthalpy change for the reaction?

broken – formed

(A) $\Delta H_{rxn} = [2(1072\frac{\text{kJ}}{\text{mol}}) + (498\ \frac{\text{kJ}}{\text{mol}})] - 2(799\ \frac{\text{kJ}}{\text{mol}})$

(B) $\Delta H_{rxn} = [2(1072\frac{\text{kJ}}{\text{mol}}) + (498\ \frac{\text{kJ}}{\text{mol}})] - 4(799\ \frac{\text{kJ}}{\text{mol}})$. 498

(C) $\Delta H_{rxn} = [2(799\ \frac{\text{kJ}}{\text{mol}}) + (142\frac{\text{kJ}}{\text{mol}})] - 4(360\ \frac{\text{kJ}}{\text{mol}})$

(D) $\Delta H_{rxn} = [2(799\ \frac{\text{kJ}}{\text{mol}}) + (142\frac{\text{kJ}}{\text{mol}})] - 2(360\ \frac{\text{kJ}}{\text{mol}})$

16. In an insulated cup of negligible heat capacity, 50. g of water at 40.°C is mixed with 30. g of water at 20.°C. The final temperature of the mixture is closest to

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(A) 22°C

(B) 27°C

(C) 30.°C

(D) 33°C

(E) 38°C

$q = mc\delta T$

$q = 50(\quad)$

$50(4.18)(\quad - 20)$

$50(4.18)(40 - x) = 30(4.18)(70 - x)$

δT δT

70