KEY

General&Analytical Chemistry I
CHMG-141

Exam 3 (V. 3)

Name_____

R = 0.0821 L. atm/mol . K

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) Calculate the amount of heat (in kJ) required to raise the temperature of a 79.0 g sample of ethanol from 298 K to 385 K. The specific heat capacity of ethanol is 2.42 J/g°C. 1) _____

A) 16.6 kJ B) 57.0 kJ C) 73.6 kJ D) 12.9 kJ E) 28.4 kJ

2) Which of the following statements is TRUE? 2) _____

A) State functions do not depend on the path taken to arrive at a particular state.
B) ΔH_{rxn} can be determined using constant pressure calorimetry.
C) Energy is neither created nor destroyed.
D) ΔE_{rxn} can be determined using constant volume calorimetry.
E) All of the above are true.

3) How much energy is required to decompose 765 g of PCl_3, according to the reaction below? The molar mass of PCl_3 is 137.32 g/mol and may be useful. 3) _____

$$4\ PCl_3(g) \rightarrow P_4(s) + 6\ Cl_2(g) \qquad \Delta H^\circ_{rxn} = +1207\ kJ$$

A) 1.68×10^3 kJ
B) 5.95×10^3 kJ
C) 6.72×10^3 kJ
D) 4.33×103 kJ
E) 2.31×10^3 kJ

4) Which of the following processes have a $\Delta S > 0$? 4) _____

A) $N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$
B) $CH_4(g) + H_2O\ (g) \rightarrow CO(g) + 3\ H_2(g)$
C) $Na_2CO_3(s) + H_2O(g) + CO_2(g) \rightarrow 2\ NaHCO_3(s)$
D) $CH_3OH(l) \rightarrow CH_3OH(s)$
E) All of the above processes have a $\Delta S > 0$.

5) Consider a reaction that has a negative ΔH and a positive ΔS. Which of the following statements is TRUE? 5) _____

A) This reaction will be nonspontaneous at all temperatures.
B) This reaction will be nonspontaneous only at high temperatures.
C) This reaction will be spontaneous only at high temperatures.
D) This reaction will be spontaneous at all temperatures.
E) It is not possible to determine without more information.

6) Which transformation is condensation? 6) _____

A) liquid → gas
B) liquid → solid
C) solid → liquid
D) gas → liquid
E) solid → gas

7) In comparing gases with liquids, gases have _____ compressibility and _____ density. 7) _____

A) smaller; smaller
B) greater; smaller
C) greater; greater
D) smaller; greater

8) Which process is endothermic? 8) _____

A) Water vapor forms ice crystals in the upper atmosphere.
B) Water condenses on the outside of a cold soda can.
C) Gasoline spilled on the ground evaporates very quickly.
D) The melted wax hardens after a candle is extinguished.
E) none of the above

9) Which of the following samples has the greatest density at STP? 9) _____

A) NO_2
B) SO_2
C) SF_6
D) Xe
E) All of these samples have the same density at STP.

10) What volume will 0.780 moles of He occupy at STP? 10) _____

A) 22.4 L B) 15.6 L C) 17.5 L D) 70.0 L E) 43.7 atm

11) Determine the oxidation state of P in PO_3^{3-}. 11) _____

A) -3 B) +2 C) +6 D) 0 E) +3

12) Determine the reducing agent in the following reaction. 12) _____

$$2\ Li(s) + Fe(C_2H_3O_2)_2(aq) \rightarrow 2\ LiC_2H_3O_2(aq) + Fe(s)$$

A) C B) H C) Fe D) O E) Li

13) All of the reactions shown are oxidation-reduction reactions **except** 13) _____

A) $2\ Zn(s) + 2\ HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$.
B) $2\ NaI(aq) + Cl_2(g) \rightarrow 2\ NaCl(aq) + I_2$.
C) $K_2SO_4(aq) + BaCl_2(aq) \rightarrow BaSO_4(s) + 2\ KCl(aq)$.
D) $2\ Fe_2O_3(s) \rightarrow 4\ Fe(s) + 3\ O_2(g)$.
E) $N_2(g) + O_2(g) \rightarrow 2\ NO(g)$.

14) The amount of energy associated with changing a liquid into a gas is called the 14) _____

A) calorie.
B) heat of combustion.
C) heat of vaporization.
D) heat of fusion.
E) joule.

15) Which of the assumptions of the kinetic-molecular theory best explains the observation that a gas can be compressed? 15) _____

A) In collisions with the walls of the container or with other molecules, energy is conserved.
B) Gas molecules move at random with no attractive forces between them.
C) The amount of space occupied by a gas is much greater than the space occupied by the actual gas molecules.
D) The velocity of gas molecules is proportional to their Kelvin temperature.
E) Collisions with the walls of the container or with other molecules are elastic.

16) How much energy is required to heat 36.0 g H_2O from a liquid at 65°C to a gas at 115°C? The following physical data may be useful. 16) _____

$\Delta H_{vap} = 40.7$ kJ/mol
$C_{liq} = 4.18$ J/g° C
$C_{gas} = 2.01$ J/g° C
$C_{sol} = 2.09$ J/g° C
$T_{melting} = 0$° C
$T_{boiling} = 100$° C

A) 10.9 kJ B) 87.7 kJ C) 52.7 kJ D) 63.5 kJ E) 91.7 kJ

17) Use the information provided to determine $\Delta H°_{rxn}$ for the following reaction: 17) _____

$$3\ Fe_2O_3(s) + CO(g) \rightarrow 2\ Fe_3O_4(s) + CO_2(g) \quad \Delta H°_{rxn} = ?$$

	$\Delta H°_f$ (kJ/mol)
$Fe_2O_3(s)$	-824
$Fe_3O_4(s)$	-1118
$CO(g)$	-111
$CO_2(g)$	-394

A) +144 kJ B) -111 kJ C) -577 kJ D) +277 kJ E) -470. kJ

-470 kJ

18) What mass of NO_2 is contained in a 13.0 L tank at 4.58 atm and 385 K? 18) _____

A) 18.8 g B) 53.1 g C) 69.2 g D) 24.4 g E) 86.7 g

19) Choose the reaction that represents $\Delta H°_f$ for $Ca(NO_3)_2$. 19) _____

A) $Ca^{2+}(aq) + 2\ NO_3^-(aq) \rightarrow Ca(NO_3)_2(aq)$

B) $Ca(s) + 2\ N(g) + 6\ O(g) \rightarrow Ca(NO_3)_2(s)$

C) $Ca(NO_3)_2(aq) \rightarrow Ca^{2+}(aq) + 2\ NO_3^-(aq)$

D) $Ca(NO_3)_2(s) \rightarrow Ca(s) + N_2(g) + 3O_2(g)$

E) $Ca(s) + N_2(g) + 3O_2(g) \rightarrow Ca(NO_3)_2(s)$

20) Use the standard reaction enthalpies given below to determine $\Delta H°_{xn}$ for the following reaction: 20) _____

$2\ S(s) + 3\ O_2(g) \rightarrow 2SO_3(g)$ $\Delta H°_{rxn} = ?$

Given:

$SO_2(g) \rightarrow S(s) + O_2(g)$ $\Delta H°_{rxn} = +296.8$ kJ

$2\ SO_2(g) + O_2(g) \rightarrow 2\ SO_3(g)$ $\Delta H°_{rxn} = -197.8$ kJ

A) -293.0 kJ B) -98.8 kJ C) -494.6 kJ D) -791.4 kJ E) -692.4 kJ

21) Which of the following is TRUE if $\Delta E_{sys} = -95$ J? 21) _____

A) The system is gaining 95 J, while the surroundings are losing 95 J.

B) The system is losing 95 J, while the surroundings are gaining 95 J.

C) Both the system and the surroundings are gaining 95 J.

D) Both the system and the surroundings are losing 95 J.

E) None of the above are true.

22. Many homes are heated using natural gas. The combustion of natural gas converts

a) Thermal energy to mechanical energy.
b) Mechanical energy to thermal energy.
c) Electrostatic energy to mechanical energy.
d) Chemical potential energy to thermal energy.
e) Thermal energy to acoustic energy.

23. Heat capacity is defined as

a) The amount of heat energy required to raise the temperature of 1 gram of substance by 1 K.
b) The amount of heat required to raise a body's (object's) temperature by 1K (or °C).
c) The amount of heat energy required to vaporize a solid or liquid.
d) The maximum amount of heat energy that a substance may absorb without decomposing.
e) 4.18 cal/g·K.

24. Water has an unusually high

a) Electrical conductivity
b) Heat of combustion
c) Specific heat capacity
d) Heat of formation

25. MgO reacts with water to form $Mg(OH)_2$. If 5.00 g MgO is combined with 100.0 g H_2O in a coffee cup calorimeter, the temperature of the resulting solution increases from 22.3 °C to 32.9 °C. Calculate the enthalpy change for the reaction per mole of MgO. Assume that the specific heat capacity of the solution is 4.184 J/g·K.

a) -37.5 kJ/mole
b) -93.0 kJ/mole
c) -577 kJ/mole
d) -1.11×10^3 kJ/mole
e) -4.65×10^3 kJ/mole

$q = m \cdot C_{sol} \cdot \Delta T$

$q = (100\,g + 5.00\,g) \cdot \left(4.184 \frac{J}{g \cdot K}\right) \cdot (32.9\,^{\circ}C - 22.3\,^{\circ}C)$

$q = 4652.3\,J$ per $5.00\,g$ of MgO

$5.0\,g\,MgO \times \frac{1\,mol\,MgO}{40.31\,g} = 0.124\,mol\,MgO$

$\Delta H = \frac{-4652\,J}{0.124\,mol} = -37516\,J = -37.5\,\frac{kJ}{mol}$

$\boxed{\Delta H = -37.5\,\frac{kJ}{mol}}$

26. (Bonus 3 points): For the following reaction

$CrO_4^{2-}(aq) + I_2(s) \rightarrow Cr(OH)_3(s) + IO_3^-(aq)$

+6 -2 0 +3 -2 +1 +5 -2

1. (0.5 point) Assign the oxidation numbers to all of the atoms in the reaction

2. (0.5 point) Split the reaction into two half-reactions; identify the atom that is oxidized and the atom that is reduced

$\underset{+6}{Cr}O_4^{2-}(aq) \rightarrow \underset{+3}{Cr}(OH)_3(s)$ GER Reduction Cr reduced.

$\underset{0}{I_2}(s) \rightarrow \underset{+5}{IO_3^-}(aq)$ LEO oxidation I oxidized

3. (0.5 point) Identify oxidizing agent and the reducing agent.

Cr - oxidizing agent

I - reducing agent

4. (1 point) Balance the given redox reaction by the Half-Reaction Method in acidic solution

See the next pages.

5. (0.5 point) How many electrons are transferred in the reaction from the reducing agent to the oxidizing agent?

30 electrons.

CrO_4^{2-} (aq) + I_2 (s) → $Cr(OH)_3$ (s) + IO_3^- (aq)

1. Separate into half reactions:

CrO_4^{2-} (aq) → $Cr(OH)_3$ (s)
+6 +3

I_2 (s) → IO_3^- (aq)
0 +5

GER reduction
LEO oxidation

CrO_4^{2-}
$x + 4(-2) = -2$
$x = 8 - 2 = (+6)$

$Cr(OH)_3$
$x + 3(-2) + 3(+1) =$
$x = (+3) = 0$

IO_3^-
$x + 3(-2) = -1$
$x = (+5)$

See also step 5

2. Balance everything but H and O

CrO_4^{2-} (aq) → $Cr(OH)_3$ (s)

I_2 (s) → 2 IO_3^- (aq)

3. Balance O with H_2O

CrO_4^{2-} (aq) → $Cr(OH)_3$ (s) + H_2O (l)

I_2 (s) + 6 H_2O (l) → 2 IO_3^- (aq)

4. Balance H with H+

CrO_4^{2-} (aq) + 5 H^+ → $Cr(OH)_3$ (s) + H_2O (l)

I_2 (s) + 6 H_2O (l) → 2 IO_3^- (aq) + 12 H^+

5. Balance charge with e-

CrO_4^{2-} (aq) + 5 H^+ + 3 e- ⟶ $Cr(OH)_3$ (s) + H_2O (l) GER

+6 → +3

I_2 (s) + 6 H_2O (l) ⟶ 2 IO_3^- (aq) + 12 H^+ + 10e- LEO

0 → +5

6. Combine to get rid of e-

10x[CrO_4^{2-} (aq) + 5 H^+ + 3 e- ⟶ $Cr(OH)_3$ (s) + H_2O (l)]

3x[I_2 (s) + 6 H_2O (l) ⟶ 2 IO_3^- (aq) + 12 H^+ + 10e-]

10 CrO_4^{2-} (aq) + 50 H^+ + 30 e- + 3 I_2 (s) + 18 H_2O (l)⟶ 10 $Cr(OH)_3$ (s) +10 H_2O (l)+ 6 IO_3^- (aq) + 36 H^+ + 30 e-

Let's clean up a little bit:

10 CrO_4^{2-} (aq) + 14 ~~50~~ H^+ + ~~30 e-~~ + 3 I_2 (s) + 8 ~~18~~ H_2O (l)⟶ 10 $Cr(OH)_3$ (s) +~~10 H_2O (l)~~+ 6 IO_3^- (aq) + ~~36 H^+ + 30 e-~~

In acidic solution

10 CrO_4^{2-} (aq) + 14 H^+ + 3 I_2 (s) + 8 H_2O (l)⟶ 10 $Cr(OH)_3$ (s) + 6 IO_3^- (aq)

In Basic solution:

7. Add OH- to neutralize H+ to both sides of the reaction:

10 CrO_4^{2-} (aq) + 14 H^+ + 3 I_2 (s) + 8 H_2O (l) + 14 OH- ⟶ 10 $Cr(OH)_3$ (s) + 6 IO_3^- (aq) + 14 OH^-

~~OHF~~

10 CrO_4^{2-} (aq) + 14 H_2O + 3 I_2 (s) + 8 H_2O (l) ⟶ 10 $Cr(OH)_3$ (s) + 6 IO_3^- (aq) + 14 OH-

10 CrO_4^{2-} (aq) + 22 H_2O + 3 I_2 (s) ⟶ 10 $Cr(OH)_3$ (s) + 6 IO_3^- (aq) + 14 OH-