

Exam

Name \_\_\_\_\_

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

1) Which one of the following compounds acts as a Bronsted-Lowry acid when dissolved in water?

- A) HF
- B) HNO<sub>2</sub>
- C) CH<sub>3</sub>COOH
- D) (CH<sub>3</sub>)<sub>3</sub>NH<sup>+</sup>
- E) all of the above

Answer: E

2) Using the data in the table, the conjugate base of which acid is the strongest base?

Acid	K <sub>a</sub>
HOAc	1.8 × 10 <sup>-5</sup>
HCHO <sub>2</sub>	1.8 × 10 <sup>-4</sup>
HCIO	3.0 × 10 <sup>-8</sup>
HF	6.8 × 10 <sup>-4</sup>

- A) F<sup>-</sup>
- B) ClO<sup>-</sup>
- C) CHO<sub>2</sub><sup>-</sup>
- D) OAc<sup>-</sup>
- E) HCIO

Answer: A

3) Of the following substances, an aqueous solution of \_\_\_\_\_ will form basic solutions.

NaHS    Cu(NO<sub>3</sub>)<sub>2</sub>    KHCO<sub>3</sub>    NaF

- A) NaHS, KHCO<sub>3</sub> and NaF
- B) NaF, KHCO<sub>3</sub>
- C) NaHS, Cu(NO<sub>3</sub>)<sub>2</sub>
- D) KHCO<sub>3</sub>, NaHS
- E) NaF only

Answer: A

4) The conjugate base of CH<sub>3</sub>NH<sub>3</sub><sup>+</sup> is \_\_\_\_\_.

- A) CH<sub>3</sub>NH<sub>2</sub>
- B) CH<sub>3</sub>NH<sub>2</sub><sup>-</sup>
- C) CH<sub>3</sub>NH<sub>2</sub><sup>+</sup>
- D) CH<sub>3</sub>NH<sup>+</sup>
- E) none of the above

Answer: A

5) The K<sub>a</sub> of acetic acid (CH<sub>3</sub>COOH) is 1.8 × 10<sup>-5</sup>. What is the pH at 25.0 °C of an aqueous solution that is 0.100 M in acetic acid?

- A) -2.87
- B) +11.13
- C) +2.87
- D) +6.61
- E) -11.13

Answer: C

6) A<sup>-</sup> is a weak base. Which equilibrium corresponds to the equilibrium constant K<sub>a</sub> for HA?

- A) A<sup>-</sup> (aq) + H<sub>3</sub>O<sup>+</sup> (aq) ⇌ HA (aq) + H<sub>2</sub>O (l)
- B) HA (aq) + H<sub>2</sub>O (l) ⇌ H<sub>3</sub>O<sup>+</sup> (aq) + A<sup>-</sup> (aq)
- C) HA (aq) + H<sub>2</sub>O (l) ⇌ H<sub>2</sub>A<sup>+</sup> (aq) + OH<sup>-</sup> (aq)
- D) A<sup>-</sup> (aq) + H<sub>2</sub>O (l) ⇌ HA (aq) + OH<sup>-</sup> (aq)
- E) A<sup>-</sup> (aq) + OH<sup>-</sup> (aq) ⇌ HOA<sup>2-</sup> (aq)

Answer: B

7) Which of the following salts will produce an acidic solution?

- A) NH<sub>4</sub>I
- B) NaNO<sub>3</sub>
- C) KBr
- D) Sr(ClO<sub>4</sub>)<sub>2</sub>
- E) K<sub>2</sub>CO<sub>3</sub>

Answer: A

8) What change will be caused by addition of a small amount of HCl to a solution containing fluoride ions and hydrogen fluoride?

- A) The concentration of hydronium ions will increase significantly.
- B) The concentration of hydrogen fluoride will increase.
- C) The concentration of hydroxyl ion will increase slightly.
- D) The fluoride ions will precipitate out of solution as its acid salt.
- E) The concentration of fluoride ion will increase.

Answer: B

9) Which of the following could be added to a solution of NaF to prepare a buffer?

- A) NaOH
- B) CH<sub>3</sub>COONa
- C) NH<sub>3</sub>
- D) KF
- E) HBr

Answer: E

10) Which solution has the greatest buffering capacity?

- A) 0.985 M NH<sub>3</sub> and 0.090 M NH<sub>4</sub>Cl
- B) 0.200 M NH<sub>3</sub> and 0.765 M NH<sub>4</sub>Cl
- C) 0.540 M NH<sub>3</sub> and 0.550 M NH<sub>4</sub>Cl
- D) 0.335 M NH<sub>3</sub> and 0.400 M NH<sub>4</sub>Cl
- E) They are all buffer solutions and would all have the same capacity.

Answer: C

Consider the following table of K<sub>sp</sub> values.

Name	Formula	K <sub>sp</sub>
Cadmium carbonate	CdCO <sub>3</sub>	5.2 × 10 <sup>-12</sup>
Cadmium hydroxide	Cd(OH) <sub>2</sub>	2.5 × 10 <sup>-14</sup>
Calcium fluoride	CaF <sub>2</sub>	3.9 × 10 <sup>-11</sup>
Silver iodide	AgI	8.3 × 10 <sup>-17</sup>
Zinc carbonate	ZnCO <sub>3</sub>	1.4 × 10 <sup>-11</sup>

11) Which compound listed below has the smallest molar solubility in water?

- A) AgI
- B) CaF<sub>2</sub>
- C) Cd(OH)<sub>2</sub>
- D) ZnCO<sub>3</sub>
- E) CdCO<sub>3</sub>

Answer: A

- 12) The pH of a solution prepared by mixing 50.0 mL of 0.125 M NaOH and 40.0 mL of 0.125 M HNO<sub>3</sub> is \_\_\_\_\_.
- A) 7.00                      B) 12.14                      C) 11.00                      D) 8.11                      E) 13.29
- Answer: B
- 13) Calculate the maximum concentration (in M) of silver ions (Ag<sup>+</sup>) in a solution that contains 0.025 M of CO<sub>3</sub><sup>2-</sup>. The K<sub>sp</sub> of Ag<sub>2</sub>CO<sub>3</sub> is 8.1 × 10<sup>-12</sup>.
- A) 3.2 × 10<sup>-10</sup>              B) 1.8 × 10<sup>-5</sup>              C) 8.1 × 10<sup>-12</sup>              D) 1.4 × 10<sup>-6</sup>              E) 2.8 × 10<sup>-6</sup>
- Answer: B
- 14) A 25.0 mL sample of 0.150 M hydrazoic acid (HN<sub>3</sub>) is titrated with a 0.150 M NaOH solution. What is the pH after 26.0 mL of base is added? The K<sub>a</sub> of hydrazoic acid is 1.9 × 10<sup>-5</sup>.
- A) 2.54                      B) 4.74                      C) 7.00                      D) 4.70                      E) 11.47
- Answer: E
- 15) In which of the following aqueous solutions would you expect AgI to have the highest solubility?
- A) 0.050 M NaI  
B) 0.010 M AgNO<sub>3</sub>  
C) 0.050 M BaI<sub>2</sub>  
D) pure water  
E) 0.050 M KI
- Answer: D
- 16) A reaction that is spontaneous as written \_\_\_\_\_.
- A) will proceed without input of matter or energy into the system  
B) is also spontaneous in the reverse direction  
C) has an equilibrium position that lies far to the left  
D) is very slow  
E) is very rapid
- Answer: A
- 17) Which of the following statements is false?
- A) The change in entropy in a system depends on the initial and final states of the system and the path taken from one state to the other.  
B) The total entropy of the universe increases in any spontaneous process.  
C) Any irreversible process results in an overall increase in entropy.  
D) Entropy increases with the number of microstates of the system.
- Answer: A
- 18) Consider a pure crystalline solid that is heated from absolute zero to a temperature above the boiling point of the liquid. Which of the following processes produces the greatest increase in the entropy of the substance?
- A) vaporizing the liquid  
B) heating the liquid  
C) heating the solid  
D) melting the solid  
E) heating the gas
- Answer: A

19)  $\Delta S$  is positive for the reaction \_\_\_\_\_.

- A)  $\text{HCl (g)} + \text{NH}_3 \text{ (g)} \rightarrow \text{NH}_4\text{Cl (s)}$
- B)  $2 \text{ Ca (s)} + \text{O}_2 \text{ (g)} \rightarrow 2 \text{ CaO (s)}$
- C)  $\text{CO}_2 \text{ (g)} \rightarrow \text{CO}_2 \text{ (s)}$
- D)  $2 \text{ KClO}_3 \text{ (s)} \rightarrow 2 \text{ KCl (s)} + 3 \text{ O}_2 \text{ (g)}$
- E)  $\text{Pb}^{2+} \text{ (aq)} + 2 \text{ Cl}^- \text{ (aq)} \rightarrow \text{PbCl}_2 \text{ (s)}$

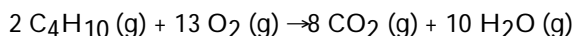
Answer: D

20) With thermodynamics, one cannot determine \_\_\_\_\_.

- A) the direction of a spontaneous reaction
- B) the speed of a reaction
- C) the temperature at which a reaction will be spontaneous
- D) the value of the equilibrium constant
- E) the theoretical yield of a reaction

Answer: B

21) For the reaction

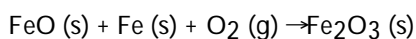


$\Delta H^\circ$  is  $-125 \text{ kJ/mol}$  and  $\Delta S^\circ$  is  $+253 \text{ J/K} \cdot \text{mol}$ . This reaction is \_\_\_\_\_.

- A) spontaneous at all temperatures
- B) spontaneous only at low temperature
- C) nonspontaneous at all temperatures
- D) spontaneous only at high temperature
- E) unable to determine without more information

Answer: A

22) Consider the reaction:



Given the following table of thermodynamic data,

Substance	$\Delta H_f^\circ$ (kJ/mol)	$S^\circ$ (J/mol · K)
FeO (s)	-271.9	60.75
Fe (s)	0	27.15
O <sub>2</sub> (g)	0	205.0
Fe <sub>2</sub> O <sub>3</sub> (s)	-822.16	89.96

determine the temperature (in  $^\circ\text{C}$ ) at which the reaction is nonspontaneous.

- A) above 2438
- B) below 2438
- C) below 618.1
- D) between 756.3 and 1051.2
- E) This reaction is spontaneous at all temperatures.

Answer: A

23) Consider the formation of solid silver chloride from aqueous silver and chloride ions.

Given the following table of thermodynamic data at 298 K:

Substance	$\Delta H_f^\circ$ (kJ/mol)	$S^\circ$ (J/K·mol)
Ag <sup>+</sup> (aq)	105.90	73.93
Cl <sup>-</sup> (aq)	-167.2	56.5
AgCl(s)	-127.0	96.11

The value of K for the reaction at 25 °C is \_\_\_\_\_. (R = 8.314 J/K·mol)

- A)  $1.8 \times 10^4$       B)  $5.3 \times 10^9$       C) 810      D)  $3.7 \times 10^{10}$       E)  $1.9 \times 10^{-10}$

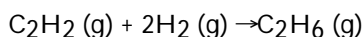
Answer: B

Use the table below to answer the questions that follow.

Thermodynamic Quantities for Selected Substances at 298.15 K (25 °C)

Substance	$\Delta H_f^\circ$ (kJ/mol)	$\Delta G_f^\circ$ (kJ/mol)	$S^\circ$ (J/K·mol)
Carbon			
C (s, diamond)	1.88	2.84	2.43
C (s, graphite)	0	0	5.69
C <sub>2</sub> H <sub>2</sub> (g)	226.7	209.2	200.8
C <sub>2</sub> H <sub>4</sub> (g)	52.30	68.11	219.4
C <sub>2</sub> H <sub>6</sub> (g)	-84.68	-32.89	229.5
CO (g)	-110.5	-137.2	197.9
CO <sub>2</sub> (g)	-393.5	-394.4	213.6
Hydrogen			
H <sub>2</sub> (g)	0	0	130.58
Oxygen			
O <sub>2</sub> (g)	0	0	205.0
H <sub>2</sub> O (l)	-285.83	-237.13	69.91

24) The value of  $\Delta S^\circ$  for the catalytic hydrogenation of acetylene to ethane,



is \_\_\_\_\_ J/K·mol.

- A) -232.5      B) -76.0      C) +440.9      D) +232.5      E) +28.7

Answer: A

25) Of the following, which is the strongest acid?

- A) HNO<sub>2</sub>      B) H<sub>2</sub>SeO<sub>4</sub>      C) H<sub>2</sub>SeO<sub>3</sub>      D) H<sub>2</sub>SO<sub>3</sub>      E) H<sub>2</sub>SO<sub>4</sub>

Answer: E