

一、單選題 (每題 4 分, 答錯不倒扣)

元素原子量: H=1, D=2, C=12, N=14, O=16, F=19, Na=23, S=32, Cl=35.5, P=31, K=39, Ca=40, Mn=55, Fe=55.85, Br=80, Rb=85.5, I=127; Faraday constant=96500 Cmol<sup>-1</sup>, Gas constant R=8.314 J K<sup>-1</sup> mol<sup>-1</sup>; 5.189×10<sup>19</sup> eV K<sup>-1</sup> mol<sup>-1</sup> or 0.082 L atm K<sup>-1</sup> mol<sup>-1</sup>, Plank Constant h=6.626×10<sup>-34</sup> J.s

[1]. Which of the following pairs is incorrect?

- A) NH<sub>4</sub>Br, ammonium bromide
- B) K<sub>2</sub>CO<sub>3</sub>, potassium carbonate
- C) BaPO<sub>4</sub>, barium phosphate
- D) CuCl, copper(I) chloride
- E) MnO<sub>2</sub>, manganese (IV) oxide

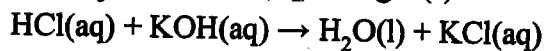
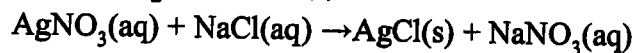
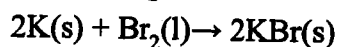
[2]. Rutherford's experiment was important because it showed that:

- A) radioactive elements give off alpha particles.
- B) gold foil can be made to be only a few atoms thick.
- C) a zinc sulfide screen scintillates when struck by a charged particle.
- D) the mass of the atom is uniformly distributed throughout the atom.
- E) an atom is mostly empty space.

[3]. The atomic mass of rhenium is 186.2. Given that 37.1% of natural rhenium is rhenium-185, what is the other stable isotope?

- A) <sup>183</sup><sub>75</sub>Re, B) <sup>187</sup><sub>75</sub>Re, C) <sup>189</sup><sub>75</sub>Re, D) <sup>181</sup><sub>75</sub>Re, E) <sup>190</sup><sub>75</sub>Re

[4]. The following reactions



are examples of

- A) precipitation reactions.
- B) redox, precipitation, and acid-base, respectively.
- C) precipitation (two) and acid-base reactions, respectively.
- D) redox reactions.
- E) none of these

- [5]. A 0.307-g sample of an unknown triprotic acid is titrated to the third equivalence point using 35.2 mL of 0.106 M NaOH. Calculate the molar mass of the acid.
- A) 247 g/mol
  - B) 171 g/mol
  - C) 165 g/mol
  - D) 151 g/mol
  - E) 82.7 g/mol
- [6]. Consider two organic molecules, ethanol and benzene. One dissolves in water and the other does not. Why?
- A) They have different molar masses.
  - B) One is ionic, the other is not.
  - C) One is an electrolyte, the other is not.
  - D) Ethanol contains a polar O—H bond, and benzene does not.
  - E) Two of these.
- [7]. Calculate the density of nitrogen at STP.
- A) 0.312 g/L
  - B) 0.625 g/L
  - C) 0.800 g/L
  - D) 1.25 g/L
  - E) 1.60 g/L
- [8]. The van der Waals equation,  $nRT = [P + (n^2 a/V^2)] (V - nb)$ , incorporates corrections to the ideal gas law in order to account for the properties of real gases. One of the corrections accounts for
- A) the possibility of chemical reaction between molecules.
  - B) the finite volume of molecules.
  - C) the quantum behavior of molecules.
  - D) the fact that average kinetic energy is inversely proportional to temperature.
  - E) the possibility of phase changes when the temperature is decreased or the pressure is increased.
- [9]. A 25.0 g piece of aluminum (which has a molar heat capacity of 24.03J/°Cmol) is heated to 82.4°C and dropped into a calorimeter containing water (specific heat capacity of water is 4.18J/g°C) initially at 22.3°C. The final temperature of the water is 24.9°C. Calculate the mass of water in the calorimeter.
- A) 118 g
  - B) 6.57 g
  - C) 3180 g
  - D) 2120 g
  - E) none of these

[10]. Calculate the lattice energy for  $\text{MgO}(s)$  using a Born-Haber cycle and the following information:

$\text{MgO}(s) \rightarrow \text{Mg}^{2+}(g) + \text{O}^{2-}(g)$	?
$\text{Mg}(s) \rightarrow \text{Mg}(g)$	+147.1 kJ/mol
$\text{Mg}(g) \rightarrow \text{Mg}^+(g) + e^-$	+737.8 kJ/mol
$\text{Mg}^+(g) \rightarrow \text{Mg}^{2+}(g) + e^-$	+1451 kJ/mol
$1/2 \text{O}_2(g) \rightarrow \text{O}(g)$	+249.0 kJ/mol
$\text{O}(g) + e^- \rightarrow \text{O}^-(g)$	-141.1 kJ/mol
$\text{O}^-(g) + e^- \rightarrow \text{O}^{2-}(g)$	+798.0 kJ/mol
$\text{Mg}(s) + 1/2 \text{O}_2(g) \rightarrow \text{MgO}(s)$	-601.8 kJ/mol

- A) +1842 kJ/mol
- B) +2444 kJ/mol
- C) +3844 kJ/mol
- D) +4108 kJ/mol

[11]. While mercury is very useful in barometers, mercury vapor is toxic. Given that mercury has a  $\Delta H_{\text{vap}}$  of 59.11 kJ/mol and its normal boiling point is 356.7°C, calculate the vapor pressure in mm Hg at room temperature, 25°C.

- A)  $2.68 \times 10^{-3}$  mm Hg
- B) 2.99 mm Hg
- C) 372 mm Hg
- D) 753 mm Hg

[12]. At a given temperature the vapor pressures of benzene and toluene are 183 mm Hg and 59.2 mm Hg, respectively. Calculate the total vapor pressure over a solution of benzene and toluene with  $X_{\text{benzene}} = 0.400$ .

- A) 110 mm Hg
- B) 133 mm Hg
- C) 109 mm Hg
- D) 242 mm Hg

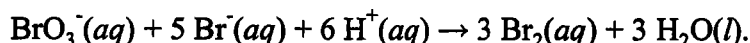
[13]. A concentration-time study of the gas phase reaction  $2 A_3 \rightarrow 3 A_2$  produced the data in the table below.

Time (s)	$[A_3]$ (M)	$[A_2]$ (M)
0	$4.00 \times 10^{-4}$	0
10	$2.00 \times 10^{-4}$	$3.00 \times 10^{-4}$
20	$1.00 \times 10^{-4}$	$4.50 \times 10^{-4}$
30	$5.00 \times 10^{-5}$	?

What is the average rate of formation of  $A_2$  in the time interval 20-30 seconds?

- A)  $6.00 \times 10^{-4}$  M/s
- B)  $5.25 \times 10^{-5}$  M/s
- C)  $7.50 \times 10^{-6}$  M/s
- D)  $6.00 \times 10^{-6}$  M/s

[14]. The following set of data was obtained by the method of initial rates for the reaction:



Calculate the initial rate when  $\text{BrO}_3^-$  is 0.30 M,  $\text{Br}^-$  is 0.050 M, and  $\text{H}^+$  is 0.15 M.

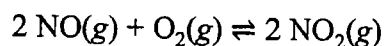
Expt	$[\text{BrO}_3^-]$ (M)	$[\text{Br}^-]$ (M)	$[\text{H}^+]$ (M)	Rate (M/s)
1	0.10	0.10	0.10	$8.0 \times 10^{-4}$
2	0.20	0.10	0.10	$1.6 \times 10^{-3}$
3	0.20	0.15	0.10	$2.4 \times 10^{-3}$
4	0.10	0.10	0.25	$5.0 \times 10^{-3}$

- A)  $6.1 \times 10^{-5}$  M/s
- B)  $2.7 \times 10^{-3}$  M/s
- C)  $5.3 \times 10^{-2}$  M/s
- D)  $8.4 \times 10^{-2}$  M/s

[15]. The first-order isomerization reaction: cyclopropane  $\rightarrow$  propene, has a rate constant of  $1.10 \times 10^{-4} \text{ s}^{-1}$  at  $470^\circ\text{C}$  and an activation energy of 264 kJ/mol. What is the temperature of the reaction when the rate constant is equal to  $4.36 \times 10^{-3} \text{ s}^{-1}$ ?

- A)  $126^\circ\text{C}$
- B)  $411^\circ\text{C}$
- C)  $510^\circ\text{C}$
- D)  $540^\circ\text{C}$

[16]. Nitric oxide reacts with oxygen to form nitrogen dioxide:



What is  $K_c'$  for the reverse reaction if the equilibrium concentration of NO is 0.300 M,  $\text{O}_2$  is 0.200 M, and  $\text{NO}_2$  is 0.530 M at 25°C?

- A) 0.0340
- B) 0.0641
- C) 0.624
- D) 15.6

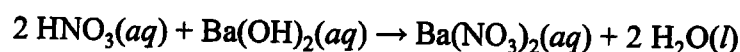
[17]. The decomposition of ammonia is:  $2 \text{NH}_3(g) \rightarrow \text{N}_2(g) + 3 \text{H}_2(g)$ . If  $K_p$  is  $1.5 \times 10^3$  at 400°C, what is the partial pressure of ammonia at equilibrium when  $\text{N}_2$  is 0.10 atm and  $\text{H}_2$  is 0.15 atm?

- A)  $2.2 \times 10^{-7}$  atm
- B)  $4.7 \times 10^{-4}$  atm
- C)  $2.1 \times 10^3$  atm
- D)  $4.4 \times 10^6$  atm

[18]. For acid solutions of the same molarity acid strength is proportional to the equilibrium concentration of  $\text{H}_3\text{O}^+$ . For equimolar solutions of acids, which equilibrium expression below corresponds to the strongest acid?

- A)  $K_c = \frac{[\text{H}_3\text{O}^+][\text{F}^-]}{[\text{HF}]} = 3.5 \times 10^{-4}$
- B)  $K_c = \frac{[\text{H}_3\text{O}^+][\text{OCl}^-]}{[\text{HOCl}]} = 3.5 \times 10^{-8}$
- C)  $K_c = \frac{[\text{H}_3\text{O}^+][\text{NO}_2^-]}{[\text{HNO}_2]} = 4.5 \times 10^{-4}$
- D)  $K_c = \frac{[\text{H}_3\text{O}^+][\text{CN}^-]}{[\text{HCN}]} = 4.9 \times 10^{-10}$

[19]. What is the strongest Brønsted-Lowry acid in the chemical reaction shown below?

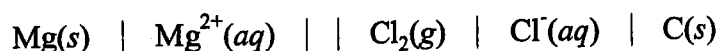


- A)  $\text{HNO}_3$
- B)  $\text{Ba}(\text{OH})_2$
- C)  $\text{Ba}(\text{NO}_3)_2$
- D)  $\text{H}_2\text{O}$

[20]. If the ionization constant of water,  $K_w$ , at  $40^\circ\text{C}$  is  $2.92 \times 10^{-14}$ , then what is the hydronium ion concentration for a neutral solution?

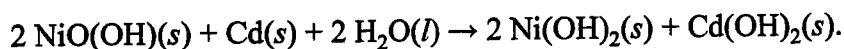
- A)  $[\text{H}_3\text{O}^+] < 1.00 \times 10^{-7} \text{ M}$   
 B)  $[\text{H}_3\text{O}^+] > 1.71 \times 10^{-7} \text{ M}$   
 C)  $[\text{H}_3\text{O}^+] = 1.71 \times 10^{-7} \text{ M}$   
 D)  $[\text{H}_3\text{O}^+] < 1.71 \times 10^{-7} \text{ M}$

[21]. What is the balanced equation for the galvanic cell reaction expressed using shorthand notation below?



- A)  $\text{Mg}(s) + 2 \text{Cl}^-(aq) \rightarrow \text{Mg}^{2+}(aq) + \text{Cl}_2(g)$   
 B)  $\text{Mg}(s) + \text{Cl}_2(g) \rightarrow \text{Mg}^{2+}(aq) + 2 \text{Cl}^-(aq)$   
 C)  $\text{Mg}^{2+}(aq) + 2 \text{Cl}^-(aq) \rightarrow \text{Mg}(s) + \text{Cl}_2(g)$   
 D)  $\text{Mg}^{2+}(aq) + 2 \text{Cl}^-(aq) \rightarrow \text{MgCl}_2(s)$

[22]. The nickel-cadmium battery cell has a standard potential of  $+1.20 \text{ V}$ . The cell reaction is



What is the standard free energy change for this reaction?

- A)  $-38.7 \text{ kJ}$   
 B)  $-116 \text{ kJ}$   
 C)  $-232 \text{ kJ}$   
 D)  $-463 \text{ kJ}$

[23]. Consider the following table of standard reduction potentials:

Reduction Half-Reaction	$E^\circ$ (V)
$\text{A}^+ + \text{e}^- \rightarrow \text{A}$	0.70
$\text{B}^{2+} + 2 \text{e}^- \rightarrow \text{B}$	0.43
$\text{C}_3 + 3 \text{e}^- \rightarrow 3 \text{C}^-$	0.27

Which substance is the strongest reducing agent?

- A) A  
 B) B  
 C)  $\text{C}_3$   
 D)  $\text{C}^-$

[24]. Beta decay of  $^{24}\text{Na}$  produces a beta particle and

- A)  $^{20}\text{F}$ .
- B)  $^{23}\text{Na}$ .
- C)  $^{24}\text{Ne}$ .
- D)  $^{24}\text{Mg}$ .

[25]. Iodine-123, used in thyroid therapy, has a half-life of 13.27 hours. How many half-lives are required for a 160 mg sample of iodine-123 to decay to 5.0 mg?

- A) 0.031
- B) 1.0
- C) 5.0
- D) 32