

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⁻¹, Gas constant R=8.314 J K⁻¹ mol⁻¹; 5.189×10¹⁹ eV K⁻¹ mol⁻¹ or 0.082 L atm K⁻¹ mol⁻¹, Plank Constant h=6.626×10⁻³⁴ J·s

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

- A) NH₄Br, ammonium bromide
- B) K₂CO₃, potassium carbonate
- C) BaPO₄, barium phosphate
- D) CuCl, copper(I) chloride
- E) MnO₂, manganese (IV) oxide

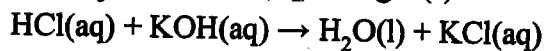
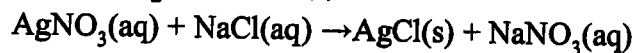
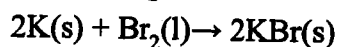
[2]. Rutherford's experiment was important because it showed that:

- 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) ¹⁸³₇₅Re, B) ¹⁸⁷₇₅Re, C) ¹⁸⁹₇₅Re, D) ¹⁸¹₇₅Re, E) ¹⁹⁰₇₅Re

[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 ΔH_{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) 2.68×10^{-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

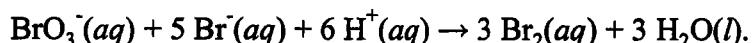
[13]. A concentration-time study of the gas phase reaction $2 A_3 \rightarrow 3 A_2$ produced the data in the table below.

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

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

- A) 6.00×10^{-4} M/s
- B) 5.25×10^{-5} M/s
- C) 7.50×10^{-6} M/s
- D) 6.00×10^{-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 BrO_3^- is 0.30 M, Br^- is 0.050 M, and H^+ is 0.15 M.

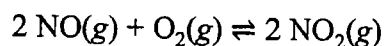
Expt	$[\text{BrO}_3^-]$ (M)	$[\text{Br}^-]$ (M)	$[\text{H}^+]$ (M)	Rate (M/s)
1	0.10	0.10	0.10	8.0×10^{-4}
2	0.20	0.10	0.10	1.6×10^{-3}
3	0.20	0.15	0.10	2.4×10^{-3}
4	0.10	0.10	0.25	5.0×10^{-3}

- A) 6.1×10^{-5} M/s
- B) 2.7×10^{-3} M/s
- C) 5.3×10^{-2} M/s
- D) 8.4×10^{-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°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°C
- B) 411°C
- C) 510°C
- D) 540°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, O_2 is 0.200 M, and NO_2 is 0.530 M at 25°C?

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

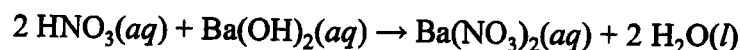
[17]. The decomposition of ammonia is: $2 \text{NH}_3(g) \rightarrow \text{N}_2(g) + 3 \text{H}_2(g)$. If K_p is 1.5×10^3 at 400°C, what is the partial pressure of ammonia at equilibrium when N_2 is 0.10 atm and H_2 is 0.15 atm?

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

[18]. For acid solutions of the same molarity acid strength is proportional to the equilibrium concentration of H_3O^+ . 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?

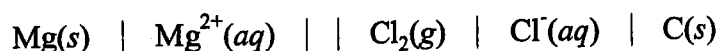


- A) HNO_3
- B) $\text{Ba}(\text{OH})_2$
- C) $\text{Ba}(\text{NO}_3)_2$
- D) H_2O

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

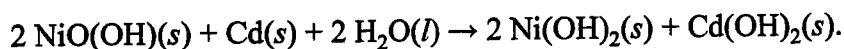
- A) $[\text{H}_3\text{O}^+] < 1.00 \times 10^{-7} \text{ M}$
 B) $[\text{H}_3\text{O}^+] > 1.71 \times 10^{-7} \text{ M}$
 C) $[\text{H}_3\text{O}^+] = 1.71 \times 10^{-7} \text{ M}$
 D) $[\text{H}_3\text{O}^+] < 1.71 \times 10^{-7} \text{ M}$

[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 kJ
 B) -116 kJ
 C) -232 kJ
 D) -463 kJ

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

Reduction Half-Reaction	E° (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) C_3
 D) C^-

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

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