

單選題(1-20)，每題 5 分，共 100 分。 ※注意：單選題考生應作答於答案卡。

1. The standard enthalpy of reaction for  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$  is  $-92.22 \text{ kJ mol}^{-1}$ . What is the change in enthalpy when 1.00 ton of  $2\text{NH}_3(\text{g})$  is formed? (A)  $\approx 5.87 \times 10^4 \text{ mol}$  (B)  $\approx -5.42 \times 10^6 \text{ kJ}$  (C)  $\approx 5.42 \text{ GJ}$  (D)  $\approx -2.71 \text{ GJ}$  (E)  $\approx -2.71 \text{ GJ mol}^{-1}$ .
2. The standard enthalpy of reaction for  $2\text{C}_2\text{H}_6(\text{g}) + 7\text{O}_2(\text{g}) \rightarrow 4\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l})$  is  $-3120 \text{ kJ mol}^{-1}$ . What is the specific enthalpy of combustion of ethane? (A)  $\approx -1560 \text{ kJ mol}^{-1}$  (B)  $\approx 1560 \text{ kJ g}^{-1}$  (C)  $\approx -51.88 \text{ kJ}$  (D)  $\approx 103.76 \text{ kJ}$  (E)  $\approx 51.88 \text{ kJ g}^{-1}$ .
3. The enthalpy of combustion of graphite is  $-393.5 \text{ kJ mol}^{-1}$ , and that of diamond is  $-395.41 \text{ kJ mol}^{-1}$ . The densities of graphite and diamond are  $2.250 \text{ g cm}^{-3}$  and  $3.510 \text{ g cm}^{-3}$ , respectively. What is the internal energy change for the transition  $\text{C}(\text{s, graphite}) \rightarrow \text{C}(\text{s, diamond})$  when the sample is under a pressure of 150 kbar? (A)  $\approx 30.65 \text{ kJ mol}^{-1}$  (B)  $\approx 1.91 \text{ kJ mol}^{-1}$  (C)  $\approx 28.74 \text{ kJ mol}^{-1}$  (D)  $\approx 1.916 \times 10^{-6} \text{ kJ mol}^{-1}$  (E)  $\approx 1.5 \times 10^{10} \text{ kJ mol}^{-1}$ .
4. From the following data, the standard enthalpy of formation of  $\text{N}_2\text{O}_5$  from  $\text{N}_2(\text{g})$  and  $\text{O}_2(\text{g})$  is calculated to be (A)  $-43.8 \text{ kJ mol}^{-1}$  (B)  $11.3 \text{ kJ mol}^{-1}$  (C)  $66.4 \text{ kJ mol}^{-1}$  (D)  $70.3 \text{ kJ mol}^{-1}$  (E)  $-55.1 \text{ kJ mol}^{-1}$ .  
 $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{NO}_2(\text{g}) \quad \Delta_r H^\circ = -114.1 \text{ kJ mol}^{-1}$   
 $4\text{NO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{N}_2\text{O}_5(\text{g}) \quad \Delta_r H^\circ = -110.2 \text{ kJ mol}^{-1}$   
 $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{NO}(\text{g}) \quad \Delta_r H^\circ = +180.5 \text{ kJ mol}^{-1}$
5. Given that the constant-pressure heat capacities of liquid water and water vapor are  $75.29 \text{ J K}^{-1} \text{ mol}^{-1}$  and  $33.58 \text{ J K}^{-1} \text{ mol}^{-1}$ , respectively, the enthalpy of vaporization of water at  $100^\circ\text{C}$  from its value at  $25^\circ\text{C}$  ( $44.01 \text{ kJ mol}^{-1}$ ) is calculated to be (A)  $-3.13 \text{ kJ mol}^{-1}$  (B)  $3.13 \text{ kJ mol}^{-1}$  (C)  $40.88 \text{ kJ mol}^{-1}$  (D)  $47.14 \text{ kJ mol}^{-1}$  (E)  $44.01 \text{ kJ mol}^{-1}$ .
6. The standard Gibbs free energy of reaction for the isomerization of borneol to isoborneol in the gas phase at  $503 \text{ K}$  is  $9.4 \text{ kJ mol}^{-1}$ . When the total pressure is 600 Torr, what is the Gibbs free energy of reaction for a mixture consisting of 0.15 mol of borneol and 0.30 mol of isoborneol? (A)  $\approx 7.38 \text{ kJ mol}^{-1}$  (B)  $\approx 2.90 \text{ kJ mol}^{-1}$  (C)  $\approx -2.90 \text{ kJ mol}^{-1}$  (D)  $\approx 12.30 \text{ kJ mol}^{-1}$  (E)  $\approx 6.50 \text{ kJ mol}^{-1}$ .
7. In the Haber process for ammonia synthesis, the equilibrium constant is  $K = 0.036$  for the reaction  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$  at  $500 \text{ K}$ . If a reactor is charged with partial pressures of 0.020 bar of  $\text{N}_2$  and 0.020 bar of  $\text{H}_2$ , what will be the equilibrium partial pressure of  $\text{H}_2$ ? (A)  $\approx 0.060 \text{ bar}$  (B)  $\approx 0.020 \text{ bar}$  (C)  $\approx 1.1 \times 10^{-3} \text{ bar}$  (D)  $\approx 7.6 \times 10^{-5} \text{ bar}$  (E)  $\approx 3.8 \times 10^{-5} \text{ bar}$ .
8. In the Haber process for ammonia synthesis, the equilibrium constant is  $K = 0.036$  for the reaction  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$  at  $500 \text{ K}$ . If a reactor is charged with partial pressures of 0.020 bar of  $\text{N}_2$  and 0.020 bar of  $\text{H}_2$ , what will be the equilibrium partial pressure of  $\text{NH}_3$ ? (A)  $\approx 0.040 \text{ bar}$  (B)  $\approx 0.020 \text{ bar}$  (C)  $\approx 1.1 \times 10^{-3} \text{ bar}$  (D)  $\approx 7.6 \times 10^{-5} \text{ bar}$  (E)  $\approx 3.8 \times 10^{-5} \text{ bar}$ .
9. The equilibrium pressure of  $\text{H}_2(\text{g})$  over a mixture of solid uranium and solid uranium hydride at  $500 \text{ K}$  is 1.04 Torr. What is the standard Gibbs free energy of formation of  $\text{UH}_3(\text{s})$  at  $500 \text{ K}$ ? (A)  $\approx -41.0 \text{ kJ mol}^{-1}$  (B)  $\approx -82.1 \text{ kJ mol}^{-1}$  (C)  $\approx 82.1 \text{ kJ mol}^{-1}$  (D)  $\approx 1.4 \times 10^{-3} \text{ kJ mol}^{-1}$  (E)  $\approx -5.8 \times 10^{-3} \text{ kJ mol}^{-1}$ .
10. What is the standard enthalpy change of a reaction for which the equilibrium constant doubles when the temperature is increased by 10 K from  $298 \text{ K}$ ? (A)  $\approx 9178.4 \text{ kJ mol}^{-1}$  (B)  $\approx 76.3 \text{ kJ mol}^{-1}$  (C)  $\approx 52.9 \text{ kJ mol}^{-1}$  (D)  $\approx -52.9 \text{ kJ mol}^{-1}$  (E)  $\approx -76.3 \text{ kJ mol}^{-1}$ .
11. The two half-reactions are:  
 $\text{Cu}^+(\text{aq}) + \text{e}^- \rightarrow \text{Cu}(\text{s}) \quad E^\circ(\text{Cu}^+, \text{Cu}) = 0.52 \text{ V}$   
 $\text{Cu}^{2+}(\text{aq}) + \text{e}^- \rightarrow \text{Cu}^+(\text{aq}) \quad E^\circ(\text{Cu}^{2+}, \text{Cu}^+) = 0.15 \text{ V}$   
What is the equilibrium constant for the disproportionation reaction  $2\text{Cu}^+(\text{aq}) \rightleftharpoons \text{Cu}(\text{s}) + \text{Cu}^{2+}(\text{aq})$  at  $298 \text{ K}$ ? (A)  $\approx 0.67$  (B)  $\approx 0.37$  (C)  $\approx 1.45$  (D)  $\approx 2.2 \times 10^4$  (E)  $\approx 1.8 \times 10^6$ .
12. The reaction is  $2\text{AgCl}(\text{s}) + \text{H}_2(\text{g}) \rightarrow 2\text{Ag}(\text{s}) + 2\text{Cl}^-(\text{aq}) + 2\text{H}^+(\text{aq})$  with a standard cell potential  $E^\circ = 0.22 \text{ V}$ . The potential of the cell  $\text{Pt}(\text{s})|\text{H}_2(\text{g})|\text{HCl}(\text{aq})|\text{AgCl}(\text{s})|\text{Ag}(\text{s})$  is  $0.312 \text{ V}$  at  $25^\circ\text{C}$ . What is the pH of the electrolyte solution? (A)  $\approx 0.78$  (B)  $\approx 1.56$  (C)  $\approx 3.12$  (D)  $\approx 6.24$  (E)  $\approx 7.00$ .
13. The molar solubility of  $\text{AgBr}$  is  $0.731 \mu\text{mol dm}^{-3}$  at  $25^\circ\text{C}$ . What is the potential of the cell

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Ag(s)|AgBr(aq)|AgBr(s)|Ag(s) at this temperature? (A)  $\approx 0.36$  V (B)  $\approx -0.73$  V (C)  $\approx -0.36$  V (D)  $\approx -0.18$  V (E)  $\approx -4.02 \times 10^{-3}$  V.

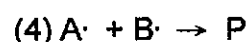
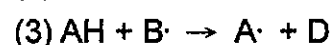
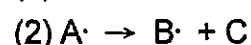
14. The standard potential of the cell Ag(s)|AgI(s)|AgI(aq)|Ag(s) is +0.9509 V at 25 °C. What is the solubility constant of AgI? (A)  $\approx 9.59 \times 10^{-5}$  (B)  $\approx 9.19 \times 10^{-9}$  (C)  $\approx 8.45 \times 10^{-17}$  (D)  $\approx 6.87 \times 10^{-33}$  (E)  $\approx 9.19 \times 10^{-9}$  mol dm<sup>-3</sup>.

15. The viscosity of water at 20 °C is 1.0019 mN s m<sup>-2</sup> and at 30 °C it is 0.7982 mN s m<sup>-2</sup>. What is the activation energy for the motion of water molecules? (A)  $\approx -8.4$  kJ mol<sup>-1</sup> (B)  $\approx 0.2$  kJ mol<sup>-1</sup> (C)  $\approx 4.2$  kJ mol<sup>-1</sup> (D)  $\approx 9.2$  kJ mol<sup>-1</sup> (E)  $\approx 16.8$  kJ mol<sup>-1</sup>.

16. What is the ratio of rates of catalyzed to noncatalyzed reactions at 37 °C, given that the Gibbs energy of activation for a particular reaction is reduced from 150 kJ mol<sup>-1</sup> to 15 kJ mol<sup>-1</sup>? (A)  $\approx 0.1$  (B)  $\approx 1.1$  (C)  $\approx 52.4$  (D)  $\approx 2.7 \times 10^{11}$  (E)  $\approx 5.4 \times 10^{22}$ .

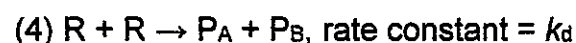
17. The enzyme-catalyzed conversion of a substrate at 25 °C has a Michaelis constant of 0.015 mol dm<sup>-3</sup> and a maximum velocity of  $4.25 \times 10^{-4}$  mol dm<sup>-3</sup> s<sup>-1</sup> when the enzyme concentration is  $3.60 \times 10^{-9}$  mol dm<sup>-3</sup>. The catalytic efficiency is calculated to be (A)  $\approx 7.9 \times 10^6$  dm<sup>3</sup> mol<sup>-1</sup> s<sup>-1</sup> (B)  $\approx 1.2 \times 10^5$  s<sup>-1</sup> (C)  $\approx 1.5 \times 10^{-2}$  mol dm<sup>-3</sup> (D)  $\approx 5.6 \times 10^{-4}$  dm<sup>3</sup> mol<sup>-1</sup> s<sup>-1</sup> (E)  $\approx 8.5 \times 10^{-6}$  s<sup>-1</sup>.

18. Consider the following chain mechanism:

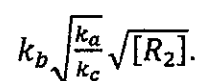
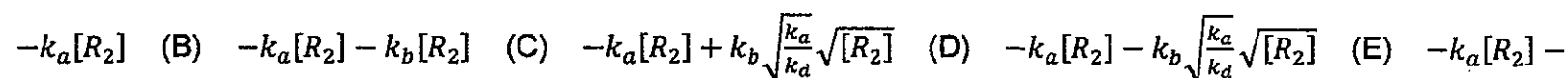


Under the steady-state approximation for the radical intermediates, what is the reaction order with respect to AH for the decomposition of AH? (A) 0.5 (B) first (C) 1.5 (D) second (E) third.

19. Consider the following mechanism for the thermal decomposition of R<sub>2</sub>:



where R<sub>2</sub>, P<sub>A</sub>, and P<sub>B</sub> are stable hydrocarbons, and R and R' are radicals. Under the steady-state approximation for the radical intermediates, what is the rate of decomposition of R<sub>2</sub> as a function of the concentration of R<sub>2</sub>? (A)



20. The atmospheric pressure is 1.00 atm and the temperature is 20.2 °C. A strip of magnesium metal (molar mass of Mg: 24.31 g mol<sup>-1</sup>) with a mass of 12.5 g is dropped into a beaker of dilute hydrochloric acid. Given that magnesium is the limiting reactant, the work done by the system as a result of the reaction is calculated to be (A)  $\approx 0.00$  kJ (B)  $\approx 0.51$  kJ (C)  $\approx -1.25$  kJ (D)  $\approx -30.49$  kJ (E)  $\approx -30.49$  kJ mol<sup>-1</sup>.

Gas constant	8.3145 J K <sup>-1</sup> mol <sup>-1</sup>
Faraday's constant	96.485 kC mol <sup>-1</sup>
1 atm = 760 Torr = 101.325 kPa	

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