

國立清華大學 105 學年度碩士班考試入學試題

系所班組別：生醫工程與環境科學系乙組 (環境與分子科學組)

考試科目 (代碼)：物理化學 (2203)

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Fundamental constants

$c = 3.0 \times 10^8$ m/s, $e = 1.6 \times 10^{-19}$ C, $N_A = 6.02 \times 10^{23}$ mol⁻¹, $R = 0.082$ atm L/(K mol) = 8.314 J/(K mol), $k = 1.38 \times 10^{-23}$ J/K, $h = 6.626 \times 10^{-34}$ Js, $m_e = 9.11 \times 10^{-31}$ kg

1. Below is a list of five of the most important scientists. Describe the significance of their contributions to physical chemistry field. (10%)

- (1) Josiah Willard Gibbs (February 11, 1839 – April 28, 1903)
- (2) Ludwig Eduard Boltzmann (February 20, 1844 – September 5, 1906)
- (3) Max Karl Ernst Ludwig Planck (April 23, 1858 – October 4, 1947)
- (4) Svante August Arrhenius (February 19, 1859 – October 2, 1927)
- (5) Henry Eyring (February 20, 1901 – December 26, 1981)

2. Consider 2 mole of an ideal monatomic gas at an initial pressure of 1.00 atm and initial temperature of 273.15 K. Assume it expands adiabatically against a constant pressure of 0.395 atm until equilibrium is reached. (a) What is the final temperature? (b) What is the final volume? (c) How much work is done on the gas in this process? (d) What is ΔU of the process? (e) What is ΔH of the process? (20%)

3. What is the temperature of the flame of a Bunsen burner fed with a mixture of hydrogen and air? In the flame the detonating gas reaction: $\text{H}_{2(g)} + 0.5 \text{O}_{2(g)} \rightarrow \text{H}_2\text{O}_{(g)}$ takes place. Assume that a stoichiometric mixture is present above the reaction and that the reaction proceeds to completion. Air is composed of 4:1 mixture of N_2 and O_2 . Assume that $\Delta_f H^\circ(\text{H}_2\text{O}_{(g)}) = -241.8$ kJ/mol at 298 K. Explain why the calculated value is higher than the observed temperature. (20%)

Table. Molar Heat Capacities as a Function of Temp: $C_{p,m} (\text{J K}^{-1} \text{mol}^{-1}) = a + bT + c/T^2$

Compound	$a/(\text{J K}^{-1} \text{mol}^{-1})$	$b/(\text{J K}^{-2} \text{mol}^{-1})$	$c/(\text{J K mol}^{-1})$
N_2 (g)	28.58	3.77×10^{-3}	-0.5×10^5
O_2 (g)	29.96	4.18×10^{-3}	-1.67×10^5
H_2 (g)	27.28	3.26×10^{-3}	0.50×10^5
H_2O (g)	30.54	10.29×10^{-3}	0

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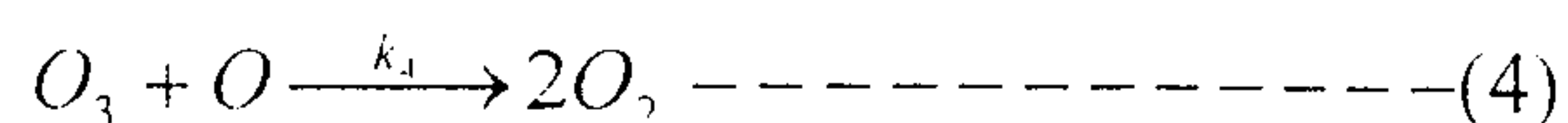
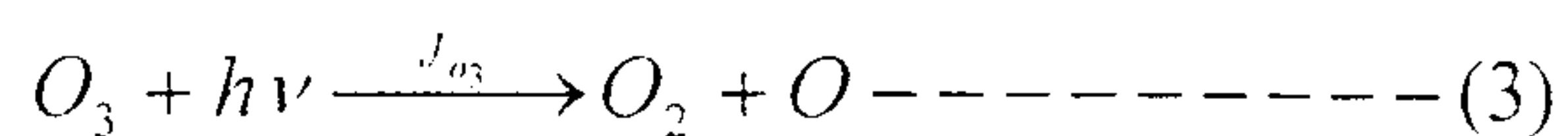
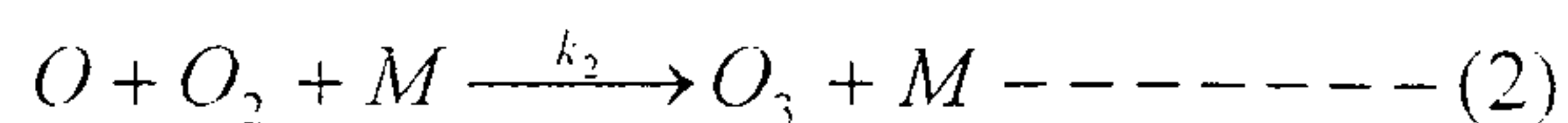
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4. The expressions that apply to the treatment of refrigerators also describe the behaviour of heat pumps, where warmth is obtained from the back of a refrigerator while its front is being used to cool the outside world. Heat pumps are popular home heating devices because they are very efficient. Compare heating of a room at 295 K by each of two methods: (a) direct conversion of 1.00 kJ of electrical energy in an electrical heater, and (b) use of 1.00 kJ of electrical energy to run a reversible heat pump with the outside at 260 K. Discuss the origin of the difference in the energy delivered to the interior of the house by the two methods. (20%)

5. Electron microscopes operate on the fact that electrons act as waves. A typical electron kinetic energy is 100 keV ($1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$). What is the wavelength of such an electron? (Ignore relativistic effects.) (15%)

6. The formation of ozone in the stratosphere is important because it absorbs ultraviolet radiation that would otherwise cause damage to life at the surface of the earth. A simplified mechanism for the formation and destruction of ozone in the stratosphere is the following:



where the J's are photodissociation constants. From experimental measurements, it is known that $J_{O_3}[O_3] \gg J_{O_2}[O_2]$ and $k_2[O][O_2][M] \gg k_4[O][O_3]$. Find a steady-state expression for the ozone concentration. (15%)