國立高雄大學 104 學年度研究所碩士班招生考試試題

科目：普通化學　　系所：應用化學系　　是否使用計算機：是

考試時間：100 分鐘　　本科原始成績：100 分

Given Tables and Equations

B = Solids　Hg = Liquids　Kr = Gases　Pm = Not found in nature

1																	18
1 H 1.00794	2											13	14	15	16	17	2 He 4.002602
3 Li 6.941	4 Be 9.012182											5 B 10.811	C 12.0107	7 N 14.00674	8 O 15.9994	9 F 18.9984032	10 Ne 20.1797
11 Na 22.989770	12 Mg 24.3050	3	4	5	6	7	8	9	10	11	12	13 Al 26.581538	14 Si 28.0855	15 P 30.973761	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.955910	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938049	26 Fe 55.845	27 Co 58.933200	28 Ni 58.6534	29 Cu 63.545	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.92160	34 Se 78.96	35 Br 79.504	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 196.56655	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.90447	54 Xe 131.29
55 Cs 132.90545	56 Ba 137.327	71 Lu 174.967	72 Hf 178.49	73 Ta 180.94.79	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.56655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.58038	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	103 Lr (262)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 Ds (269)	111 Rg (272)	112 Cn (277)	113 Uut (277)	114 Uuq (277)	115 Uup (277)	116 Uuh (277)		118 Uuo (277)

57 La 138.9055	58 Ce 140.116	59 Pr 140.50765	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.92534	66 Dy 162.50	67 Ho 164.93032	68 Er 167.26	69 Tm 168.93421	70 Yb 173.04
89 Ac 232.0381	90 Th 232.0381	91 Pa 231.035888	92 U 238.0289	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)

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Given equations:

h = 6.626 × 10^{-34} J s or 6.626 × 10^{-34} kg m^2/s, Neutron mass=1.67 × 10^{-27} kg; λ=h/mv; *ΔE* = energy level of n_{final}−energy level $n_{initial}$;

E = −2.178 × 10^{-18} J (Z^2/n^2); C = vλ; E = *h*c/ λ; kE $_{electron}$=1/2 mv^2;

Δx • Δp ≥ ħ/2　ħ=h/2*π*; F=96485 C; $q_{rev}=nRT\ln(V_2/V_1)$, ΔE=q+w; $w=-p\Delta V$; $\Delta V=V_f-V_i$;

$\frac{nRT_1}{P_2}-\frac{nRT_1}{P_1}=nRT_1(\frac{1}{P_2}-\frac{1}{P_1})$; $\Delta S=nC_v\ln\frac{T_2}{T_1}$; $\Delta S=nR\ln\frac{V_2}{V_1}$; $\Delta S=nC_p\ln\frac{T_2}{T_1}$; $\Delta S=nR\ln\frac{P_1}{P_2}$;

$\Delta G=\Delta H-T\Delta S$; $101.35\frac{J}{Latm}$;

Mass of electron: 9.11 x 10^{-31}kg, R=0.08206 L atm $mol^{-1}K^{-1}$, 8.3145 J K^{-1} mol^{-1}, Z_A=1/4 $(N/V)A(8RT/\pi M)^{1/2}$, $f(u)=4\pi(m/2\pi k_BT)^{3/2}u^2e(-mu^2/2k_BT)$, $(KE)_{avg}=3/2RT$, Force per impact=ma= $(m\Delta u/\Delta t)$, $u=(3RT/M)^{1/2}$, $(2RT/M)^{1/2}$, $(8RT/\pi M)^{1/2}$, $V_{sphere}=4/3\pi r^3$,

$$\Delta E=nCv\Delta T=n(\frac{3}{2})R\frac{\Delta(PV)}{nR}$$

$$P\Delta V=nR\Delta T$$

$$\frac{101.3J}{Latm}$$

$$\Delta H=nCp\Delta T$$

$$\Delta H=mS\Delta T$$

$$\Delta E=nCv\Delta T$$

$$\Delta E=q+w$$

$$E_n=\frac{n^2h^2}{8mL^2}$$

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Directions: For each question, <u>select the best answer</u>.

1. At a particular temperature a 2.00-L flask at equilibrium contains 2.80×10^{-4} mol N_2, 2.50×10^{-5} mol O_2, and 2.00×10^{-2} mol N_2O. Calculate K at this temperature for the reaction

$$2N_2(g) + O_2(g) \rightleftharpoons 2N_2O(g)$$

If $[N_2] = 2.00 \times 10^{-4}$ M, $[N_2O] = 0.200$ M, and $[O_2] = 0.00245$ M, does this represent a system at equilibrium?

A. No, the reaction shifts to the right.
B. Yes, this represents a system at equilibrium.
C. No, the reaction shifts to the left.
D. Yes, the reaction will stop.
E. Yes, the reaction is at the equilibrium and $[O_2] = 0$.

2. At a particular temperature, $K_p = 2.0 \times 10^{-6}$ atm for the reaction

$$2CO_2(g) \rightleftharpoons 2CO(g) + O_2(g)$$

If 2.0 mol of CO_2 is initially placed into a 5.0-L vessel, calculate the equilibrium concentration of all species.

A. $[CO_2]_{eq} = 0.93$M, $[CO]_{eq} = 0.086$M, $[O_2]_{eq} = 0.035$M
B. $[CO_2]_{eq} = 0.39$M, $[CO]_{eq} = 0.086$M, $[O_2]_{eq} = 0.043$M
C. $[CO_2]_{eq} = 0.30$M, $[CO]_{eq} = 0.068$M, $[O_2]_{eq} = 0.004$M
D. $[CO_2]_{eq} = 0.39$M, $[CO]_{eq} = 0.0086$M, $[O_2]_{eq} = 0.0043$M
E. $[CO_2]_{eq} = 0.39$M, $[CO]_{eq} = 0.0076$M, $[O_2]_{eq} = 0.0055$M

3. A sample of gaseous PCl_5 was introduced into an evacuated flask so that the pressure of pure PCl_5 would be 0.5 atm at 523 K. However, PCl_5 decomposed to gaseous PCl_3 and Cl_2, and the actual pressure in the flask was found to be 0.84 atm. Calculate K_p for the decomposition reaction at 523 K. Also calculate K at this reaction.

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

A. K_p = 0.60 atm, K=2.3 × 10^{-2} mol/L
B. K_p = 0.72 atm, K=1.0 × 10^{-2} mol/L
C. K_p = 0.72 atm, K=1.7 × 10^{-2} mol/L
D. K_p = 0.85 atm, K=2.8 × 10^{-2} mol/L
E. K_p = 0.64 atm, K=1.2 × 10^{-2} mol/L

4. In which direction will the position of the equilibrium

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

shift for each of the following changed conditions?

i. H_2(g) is added.
ii. I_2(g) is removed.
iii. HI(g) is removed.
iv. Some Ar(g) is added.
v. The volume of the container is doubled.
vi. The temperature is decreased (the reaction is exothermic)

A. i.) left, ii.) left, iii.) left, iv.)left, v.) left, vi.)right,
B. i.)right, ii.) left, iii.) left, iv.)left, v.) left, vi.)no effect,
C. i.) left, ii.) right, iii.) left, iv.)no effect, v.) no effect, vi.)left,
D. i.) left, ii.) right, iii.) left, iv.)no effect, v.) no effect, vi.)right,
E. i.) right, ii.) no effect, iii.) left, iv.)left, v.) left, vi.), left

5. Lexan is a plastic used to make compact discs, eyeglass lenses, and bullet-proof glass. One of the compounds used to make Lexan is phosgene ($COCl_2$), a poisonous gas. Phosgene is produced by the reaction

$$CO(g)+Cl_2(g) \rightleftharpoons COCl_2(g)$$

for which K = 4.5 ×10^9 L/mol at 100. °C and K_p=1.5 × 10^8 atm^{-1}.
Equal moles of CO and Cl_2 are reacted at 100. °C. If the total pressure at equilibrium is 5.0 atm, calculate the equilibrium partial pressure of all the gases.

A. P_{CO}=1.8 x 10^{-4} atm, P_{Cl2}=1.8 x 10^{-4} atm, P_{COCl2}=5.0 atm
B. P_{CO}=1.8 x 10^{-5} atm, P_{Cl2}=1.8 x 10^{-5} atm, P_{COCl2}=5.0 atm
C. P_{CO}=5.0 atm, P_{Cl2}=1.8 x 10^{-4} atm, P_{COCl2}=5.0 atm
D. P_{CO}=1.8 x 10^{-5} atm, P_{Cl2}=5.0 atm, P_{COCl2}=5.0 atm
E. P_{CO}=1.8 x 10^{-4} atm, P_{Cl2}=5.0 atm, P_{COCl2}=5.0 atm

6. Using table 7.2, arrange these species according to their strength as bases H_2O, F^-, Cl^-, NO_2^-, and CN^-.

TABLE 7.2 Values of K_a for Some Common Monoprotic Acids

Formula	Name	Value of K_a
HSO_4^-	Hydrogen sulfate ion	1.2×10^{-2}
$HClO_2$	Chlorous acid	1.2×10^{-2}
$HC_2H_2ClO_2$	Monochloracetic acid	1.35×10^{-3}
HF	Hydrofluoric acid	7.2×10^{-4}
HNO_2	Nitrous acid	4.0×10^{-4}
$HC_2H_3O_2$	Acetic acid	1.8×10^{-5}
$[Al(H_2O)_6]^{3+}$	Hydrated aluminum(III) ion	1.4×10^{-5}
HOCl	Hypochlorous acid	3.5×10^{-8}
HCN	Hydrocyanic acid	6.2×10^{-10}
NH_4^+	Ammonium ion	5.6×10^{-10}
HOC_6H_5	Phenol	1.6×10^{-10}

Increasing acid strength ↑

a. $Cl^- < H_2O < F^- < NO_2^- < CN^-$.
b. $F^- < H_2O < Cl^- < NO_2^- < CN^-$.
c. $NO_2 < F^- < Cl^- < H_2O < CN^-$.
d. $CN^- < F^- < Cl^- < NO_2^- < H_2O$.
e. $Cl^- < F^- < NO_2^- < H_2O < CN^-$.
f. $Cl^- < F^- < H_2O < NO_2^- < CN^-$.

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7. Calculate the pKa of the conjugate acid of water, H_3O^+.

A. -1.85
B. 1.85
C. -1.74
D. 1.74
E. 7.00

8. What is the pH of 1.0 $x10^{-11}$ M HI in water.

A. 11.00
B. 3.98
C. 6.00
D. 5.50
E. 7.00

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9. Calculate the fraction of CO_3^{2-}: HCO_3^- at pH=9.00

Given

$$H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

Assume

$$Ka_1 = \frac{[H^+][HCO_3^-]}{[H_2CO_3]} = 4.3 \times 10^{-7}$$

$$HCO_3^-(aq) \rightleftharpoons H^+(aq) + CO_3^{2-}(aq)$$

Assume

$$Ka_2 = \frac{[H^+][CO_3^{2-}]}{[HCO_3^-]} = 4.8 \times 10^{-11}$$

$$CO_2(aq) + H_2O \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

A. 4.8×10^{-2}
B. 3.8×10^{-2}
C. 0.95
D. 2.3×10^{-3}
E. 4.8×10^{-11}

10. Calculate the fraction of HCO_3^-, and at pH=8.00

Given

$$H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

Assume

$$Ka_1 = \frac{[H^+][HCO_3^-]}{[H_2CO_3]} = 2.6 \times 10^{-5}$$

$$HCO_3^-(aq) \rightleftharpoons H^+(aq) + CO_3^{2-}(aq)$$

Assume

$$Ka_2 = \frac{[H^+][CO_3^{2-}]}{[HCO_3^-]} = 3.2 \times 10^{-9}$$

$$CO_2(aq) + H_2O \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

A. 0.95
B. 0.83
C. 0.76
D. 0.42
E. 0.59

11. The principal equilibrium in a solution of $NaHCO_3$ is

$$HCO_3^-(aq) + HCO_3^-(aq) \rightleftharpoons H_2CO_3(aq) + CO_3^{2-}(aq)$$

Where $Ka_1 = 5.2\times10^{-9}$, $Ka_2 = 3.3\times10^{-11}$.

What is the value of the equilibrium constant for this reaction?

A. 6.4×10^{-3}
B. 8.7×10^{-4}
C. 3.3×10^{-2}
D. 1.1×10^{-4}
E. 1.1×10^{-3}

12. Assume a 0.100 M solution of $NH_4C_2H_3O_2$ has a pH of 8.00.
NH_3 is a weak base and $C_2H_3O_2^-$ is the anion of a weak acid.
Calculate the K_b of $C_2H_3O_2^-$, assume that the K_b of $NH_3 = 1.0\times10^{-3}$.

A. 1.0×10^{-9}
B. 1.0×10^{5}
C. 1.0×10^{-5}
D. 1.0×10^{9}
E. 1.0×10^{-3}

13. Classify each of the following as a strong acid, weak acid, strong base, or a weak base in aqueous solution.

i. HNO_2　ii. HNO_3　iii. CH_3NH_2　iv. NaOH　v. NH_3
vi. HF　vii. HCO_2H　viii. $Ca(OH)_2$　ix. H_2SO_4

A. strong acid or base: ii, iv, viii, ix ; weak acid or base: i, iii, v, vi, vii
B. strong acid or base: i, ii , iii, v, vii,; weak acid or base: iv, vi, viii, ix
C. strong acid or base: ii, iv, vi, ix ; weak acid or base: i, iii, v, vii,viii
D. strong acid or base: ii, iv, vi, vii, ix ; weak acid or base: i, iii, v, viii
E. strong acid or base: ii, iv, vi, viii, ix ; weak acid or base: i, iii, v, vii

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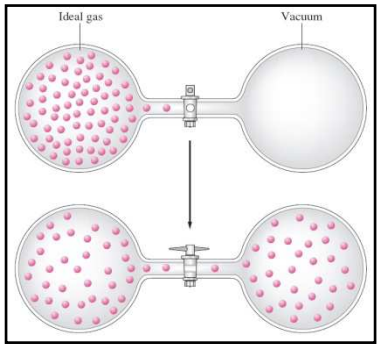
14. At 40.°C the value of K_w is 2.92×10^{-14}. If the hydroxide ion concentration in a solution is 0.10 M, what is the pH at 40. °C?

A. pH = 11.53
B. pH = 7.00
C. pH = 10.34
D. pH = 12.53
E. pH = 6.77

15. How much volume of concentrated (12 M)HCl into 1600 mL of water, to get a pH = 1.50 solution?

A. 5.0 mL
B. 4.2 mL
C. 4.7 mL
D. 6.3 mL
E. 1.2 mL

16. In a two bulb system shown below with total n particles, the probability of finding all the molecules of gas in the left bulb after opening the valve is defined as



A. $\frac{1}{2^n} = \left(\frac{1}{2}\right)^n$

B. $\frac{1}{3^n} = \left(\frac{1}{3}\right)^n$

C. $(\frac{1}{3})^{6x10^{23}}$

D. $\frac{1}{2}\log(10)^{6x10^{23}}$

E. $\frac{1}{2}\ln^{6x10^{23}}$

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17. The work function of an element is the energy required to remove and electron from the surface of the solid. The work function for lithium is 279.7 kJ/mol. (that is, it takes 279.7 kJ of energy to remove one mole of electrons from one mole of Li atoms on the surface of Li metal) What is the **maximum wavelength of light** that can remove an electron from an atom in lithium metal?

A. 1 nm
B. 428 nm
C. 2 pm
D. 500 pm
E. 5 m

18. Which one is the correct systematic name for HClO?
A. perchlorate
B. chlorate
C. chloric acid
D. hypochlorous acid
E. chlorous acid

19.Which of the following are the correct names of the following compounds?
$CoBr_2$, $CaCl_2$, Al_2O_3, $CrCl_3$
A. cobalt(II) bromide, calcium chloride, aluminum oxide, chromium(III)chloride
B. cobalt bromide, calcium chloride, aluminum oxide, chromium trichloride
C. cobalt(I) dibromide, calcium chloride, aluminum oxide, chromium(III)chloride
D. cobalt(II)bromide, calcium(I) chloride, aluminum oxide, chromium(III)chloride
E. cobalt(II)bromide, calcium chloride, aluminum(III) oxide, chromium(III)chloride

20. The most accurate method for comparing masses of atoms is the use of the
A. a scale
B. elemental analyses
C. x-ray spectrometer
D. combustion device
E. mass spectrometer