Booklet A **KIM101E** **Midterm-2** **Dec. 24, 2023**

Group Number	:	Surname	:	Signature
List Number	:	Name	:	
Student Number	:	e-mail	:	

	1												13	14	15	16	17	18
1	1 H 1,008	2																2 He 4,003
2	3 Li 6,94	4 Be 9,012											5 B 10,81	6 C 12,01	7 N 14,01	8 O 16,00	9 F 19,00	10 Ne 20,18
3	11 Na 22,99	12 Mg 24,31	3	4	5	6	7	8	9	10	11	12	13 Al 26,98	14 Si 28,09	15 P 30,97	16 S 32,06	17 Cl 35,45	18 Ar 39,95
4	19 K 39,10	20 Ca 40,08	21 Sc 44,96	22 Ti 47,87	23 V 50,94	24 Cr 52,00	25 Mn 54,94	26 Fe 55,85	27 Co 58,93	28 Ni 58,69	29 Cu 63,55	30 Zn 65,38	31 Ga 69,72	32 Ge 72,63	33 As 74,92	34 Se 78,97	35 Br 79,90	36 Kr 83,80
5	37 Rb 85,47	38 Sr 87,62	39 Y 88,91	40 Zr 91,22	41 Nb 92,91	42 Mo 95,95	43 Tc	44 Ru 101,1	45 Rh 102,9	46 Pd 106,4	47 Ag 107,9	48 Cd 112,4	49 In 114,8	50 Sn 118,7	51 Sb 121,8	52 Te 127,6	53 I 126,9	54 Xe 131,3
6	55 Cs 132,9	56 Ba 137,3	57–71	72 Hf 178,5	73 Ta 180,9	74 W 183,8	75 Re 186,2	76 Os 190,2	77 Ir 192,2	78 Pt 195,1	79 Au 197,0	80 Hg 200,6	81 Tl 204,4	82 Pb 207,2	83 Bi 209,0	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89–103	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

	57 La 138,9	58 Ce 140,1	59 Pr 140,9	60 Nd 144,2	61 Pm	62 Sm 150,4	63 Eu 152,0	64 Gd 157,3	65 Tb 158,9	66 Dy 162,5	67 Ho 164,9	68 Er 167,3	69 Tm 168,9	70 Yb 173,0	71 Lu 175,0
	89 Ac	90 Th 232,0	91 Pa 231,0	92 U 238,0	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

$c = 2.998\times10^{8}$ m s^{-1} $g = 9.8$ m s^{-2} $h = 6.626\times10^{-34}$ J s $R_H = 2.179\times10^{-18}$ J 0 °C = 273.15 K

$N_A = 6.02\times10^{23}$ 1 cal = 4.184 J 1 m = 10^9 nm = 10^{10} Å = 10^{12} pm 1 g = 10^3 mg = 10^6 µg

1 atm = 760 mmHg = 760 torr = 101325 Pa = 101.325 kPa = 1.01325 bar

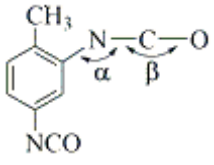
1 atm.L = 101.325 J

R = 0.08206 L atm mol^{-1} K^{-1} = 0.08314 L bar mol^{-1} K^{-1} = 8.314 J mol^{-1} K^{-1} = 8.314 L kPa mol^{-1} K^{-1}

For water: c = 4.184 J g^{-1} K^{-1} $K_f = 1.86$ K kg mol^{-1} $K_b = 0.512$ K kg mol^{-1}

1 Newton (N) = 1 kg m s^{-2} 1 Joule (J) = 1 N m = 1 kg m^2 s^{-2} 1 Watt (W) = 1 J s^{-1}

1) Toluene-2,4-diisocyanate is used in the manufacture of polyurethane foam. An ***incomplete*** structure is shown on the right side. What are the values of the bond angles marked α and β in the compound?



A) α = 120°, β = 180°
B) α = 120°, β = 120°
C) α = 109.5°, β = 120°
D) α = 109.5°, β = 180°
E) α = 180°, β = 120°

2) If the atomic radius of Aluminum which crystallizes in a face-centered-cubic unit cell is r, what is the volume of the unit cell?

A) $\left(\frac{2r}{\sqrt{2}}\right)^3$ B) $\left(\frac{4r}{\sqrt{2}}\right)^3$ C) $\left(\frac{2r}{\sqrt{3}}\right)^3$ D) $\left(\frac{4r}{\sqrt{3}}\right)^3$ E) $\left(\frac{3r}{\sqrt{2}}\right)^3$

3) A 0.72 g sample of polyvinyl chloride (PVC, non-electrolyte) is dissolved in 250 mL of a suitable solvent at 25°C. The solution has an osmotic pressure of 1.67 mmHg. What is the molar mass of PVC?
   A) 2.7×10^{-3} g/mol
   B) 2.7×10^{3} g/mol
   C) 2.7×10^{4} g/mol
   D) 3.5×10^{4} g/mol
   E) 3.2×10^{4} g/mol

4) Which of the following species has bond order **2** according to molecular orbital theory? N_2, N_2^{2+}, N_2^{3+}, N_2^{-}, N_2^{2-}
   A) Only N_2^{2+} B) N_2 and N_2^{-} C) N_2^{3+} and N_2^{2-} D) N_2^{2+} and N_2^{2-} E) N_2^{-} and N_2^{2-}

5) Which of the following compounds has the same central atom hybridization as in the XeF_3^{+} molecule?
   A) ClO_2^{-} B) SnI_2 C) POF_3 D) IF_2^{+} E) ICl_2^{-}

6) Which of the following compounds can form hydrogen bonding?
   A) O_3 B) NO C) $CH_2{=}CH_2$ D) NH_3 E) $H_3C\text{-}O\text{-}CH_3$

7) The atomic radius of a face-centered-cubic metal is $\frac{\sqrt{2}}{10}$ nm. The atomic mass of the metal is 24.092 g/mol. What is the density of the metal in kg/m^3?
   A) 2500 kg/m^3 B) 250 kg/m^3 C) 25 kg/m^3 D) 2.5 kg/m^3 E) 0.25 kg/m^3

8) A piece of stainless steel (c_p = 0.50 J g^{-1} °C^{-1}) is transferred from an oven at 201°C into 150 mL of water at 23.2°C. The water temperature rises to 55.4°C. What is the mass of the steel?
   A) 5.67×10^{3} kg B) 2.8×10^{2} g C) 5.67×10^{3} g D) 2.8×10^{2} kg E) 2.8 g

9) Which of the following molecules has the square planar geometry?
   A) SF_4 B) CH_4 C) XeF_4 D) XeO_4 E) ClO_4^{-}

10) Arrange the following in the order of increasing boiling point: Ne, O_2, He, Cl_2, $(CH_3)_2CO$, O_3
   A) He < O_2 < Ne < O_3 < Cl_2 < $(CH_3)_2CO$
   B) He < Ne < O_2 < O_3 < Cl_2 < $(CH_3)_2CO$
   C) He < Ne < O_3 < O_2 < Cl_2 < $(CH_3)_2CO$
   D) $(CH_3)_2CO$ < Cl_2 < O_3 < O_2 < Ne < He
   E) $(CH_3)_2CO$ < Cl_2 < O_2 < O_3 < Ne < He

11) Which of the following molecules has the smallest bond angle?
   A) XeF_2 B) BF_3 C) CN^{-} D) H_2O E) SO_3

12) The vapor pressure of pure water at 85°C is 434 torr. What is the vapor pressure 85°C of a solution prepared from 100 mL of water and 150 g of diglyme, $C_6H_{14}O_3$, a non-volatile substance?
   A) 73 Torr B) 88 Torr C) 361 Torr D) 401 Torr E) 434 Torr

13) Consider an aluminum sphere with a mass of 0.047 kg initially heated to 100°C. Subsequently, the heated sphere is released into a copper calorimeter which has a mass of 0.14 kg and contains 0.25 kg of water at an initial temperature of 20°C. As the system reaches thermal equilibrium, the temperature of the water stabilizes at 23°C. Determine the specific heat capacity of aluminum, given the specific heat capacities of copper as 0.386×10^{3} J kg^{-1}°C^{-1}.
   A) 119 J kg^{-1}°C^{-1}
   B) 45.66 J kg^{-1}°C^{-1}
   C) 0.911 J kg^{-1}°C^{-1}
   D) 911 J kg^{-1}°C^{-1}
   E) 0.119 J kg^{-1}°C^{-1}

14) Calculate the value of $\Delta H°$ for the following reaction

$P_4O_{10}\,(s) + 6PCl_5\,(g) \rightarrow 10POCl_3\,(g)$ using the following equations:

(*i*) $P_4\,(s) + 6Cl_2\,(g) \rightarrow 4PCl_3\,(g)$ $\Delta H° = -1225.6$ kJ/mol

(*ii*) $P_4\,(s) + 5O_2\,(g) \rightarrow P_4O_{10}\,(s)$ $\Delta H° = -2967.3$ kJ/mol

(*iii*) $PCl_3\,(g) + Cl_2\,(g) \rightarrow PCl_5\,(g)$ $\Delta H° = -84.2$ kJ/mol

(*iv*) $PCl_3\,(g) + ½\,O_2\,(g) \rightarrow POCl_3\,(g)$ $\Delta H° = -285.7$ kJ/mol

A) -610.1 kJ B) -2857.0 kJ C) 1620.5 kJ D) 1841.1 kJ E) 5103.9 kJ

15) Methanol has a normal boiling point of 64.6°C and heat of vaporization (ΔH_{vap}) of 35.2 kJ/mol. What is the vapor pressure of methanol at 12.0°C?

A) 75.3 mmHg B) 86.9 mmHg C) 186.9 mmHg D) 900.1 mmHg E) 767.4 mmHg

16) A fountain in front of the Mustafa Inan library at I.T.U., Ayazaga, has pool water at 10 m^3 volume. A couple of years ago, winter was very severe and night temperatures fell to -6°C. What is the minimum mass of salt, NaCl, in kilograms that should be added to the fountain water to keep it from freezing? $d_{water} = 1$ g/cm^3

A) 1613 kg B) 944 x 10^3 kg C) 1887 x 10^3 kg D) 1887 kg E) 944 kg

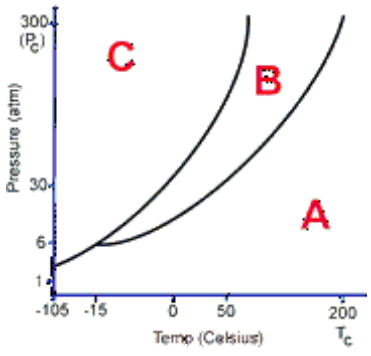
17) Determine the change in internal energy (ΔU) for the transformation of 1 mol of water at 100°C to steam under 1 atm pressure. The heat of vaporization for water at 100°C is 40.670 kJ mol^{-1}. Assume steam behaves ideal gas and the density of water as 1 g/mL.

A) 3.098 kJ B) 21.884 kJ C) 30.582 kJ D) 43.768 kJ E) 37.572 kJ

18) Determine the work performed in kilojoules when an external pressure of 2.50 atm is applied, at a constant temperature of 20.0°C, to 50.0 g of $N_2\,(g)$ in a 75.0 L cylinder.

A) +1.44 kJ B) -0.14 kJ C) +14.6 kJ D) +0.14 kJ E) -14.6 kJ

19) Due to the phase diagram given below, if the temperature of the substance is held constant at -15°C, what would be the phase change with a pressure increase from 1 atm to 30 atm?



A) sublimation B) melting C) deposition D) condensation E) freezing

20) Which of the following is true for the SO_3 molecule?

I) Molecular geometry is trigonal planar. **II)** The molecular geometry is a trigonal pyramidal.

III) The molecule is nonpolar. **IV)** Intramolecular bonds are polar.

V) The bond angles in the molecule are greater than 120°.

A) I, III B) II, IV, V C) I, IV, V D) I, III, IV E) II, III, IV

Answer Key
Testname: 24DECEMBER-MIDTERM-2-ENA

1) A
2) B
3) E
4) D
5) E
6) D
7) A
8) B
9) C
10) B
11) D
12) C
13) D
14) A
15) A
16) E
17) E
18) C
19) C
20) D