KEY

Chemistry 1A, Fall 2006

Midterm 1, Version A

Sept 19, 2006

(90 min, closed book)

Name:___________________

SID:_____________________

TA Name:________________

- There are 24 Multiple choice questions worth 2.5 points each.
- There are 4, multi-part short answer questions.
- For the multiple choice section, fill in the Scantron form AND circle your answer on the exam.
- Put your final answers in the boxes provided. Full credit cannot be gained for answers outside the boxes provided.
- The homework and chemquizzes that each question is based upon is listed after the question e.g. [HW 1.13, CQ 7.3]

Question	Score
Multiple Choice Section	
Question 25	
Question 26	
Question 27	
Question 28	
Total	

Quantum:

$E = h\nu$

$\lambda\nu = c$

$\lambda_{deBroglie} = h / p = h / mv$

E_{kin} (e-) $= h\nu - \Phi = h\nu - h\nu_0$

$$E_n = -\frac{Z^2}{n^2} R_\infty$$

$\Delta x\, \Delta p \sim h$

$p = mv$

Particle in a box (1-D Quantum):

$E_n = h^2n^2/8mL^2$; n = 1, 2, 3...

Vibrational:

$E_v = (v + ½)\, hA/2\pi$; $A = (k/m)^{½}$

Rotational:

$E_n = n(n + 1)\, hB$; $B = h/8\pi^2 I$; $I = 2mr^2$

$m = m_Am_B/(m_A + m_B)$

Ideal Gas:

$PV = nRT$

$$E_{kin} = \frac{3}{2} RT$$

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

Contants:

$N_0 = 6.02214 \times 10^{23}\ mol^{-1}$

$R_\infty = 2.179874 \times 10^{-18}$ J

$R_\infty = 3.28984 \times 10^{15}$ Hz

$k = 1.38066 \times 10^{-23}\ J\ K^{-1}$

$h = 6.62608 \times 10^{-34}$ J s

$m_e = 9.101939 \times 10^{-31}$ kg

$c = 2.99792 \times 10^8\ m\ s^{-1}$

T (K) = T (C) + 273.15

F = 96,485 C / mol

1 V = 1 J / C

Gas Constant:

$R = 8.31451\ J\ K^{-1}\ mol^{-1}$

$R = 8.20578 \times 10^{-2}\ L\ atm\ K^{-1}\ mol^{-1}$

$1\ nm = 10^{-9}$ m

1 kJ = 1000 J

1 atm = 760 mm Hg = 760 torr ≈ 1 bar

1 L atm ≈ 100 J

Thermodynamics:

$\Delta G° = \Delta H° - T\Delta S°$

$\Delta H° = \Sigma\, \Delta H°_f$ (products) $- \Sigma\, \Delta H°_f$ (reactants)

$\Delta S° = \Sigma\, S°$ (products) $- \Sigma\, S°$ (reactants)

$\Delta G° = \Sigma\, \Delta G°_f$ (products) $- \Sigma\, \Delta G°_f$ (reactants)

$S = k_B \ln W$

$\Delta S = q_{rev}/T$

$\Delta E = q + w$

$w = -P_{ext}\Delta V$

for $aA + bB \rightleftarrows cC + dD$

$$Q = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$ At equilibrium, Q = K

$\Delta G = \Delta G° + RT\ln Q$

$G = G° + RT\ln(a)$; a = activity $= \gamma P/P°$ or $\gamma[A]/[A]°$

$\Delta G° = -RT\ln K$

$\Delta G° = -nF\Delta Є°$

$\Delta Є = \Delta Є° - (RT/nF) \ln Q$

$$\ln K = -\frac{\Delta H°}{R}\frac{1}{T} + \frac{\Delta S°}{R}$$

$\Delta T = ik_{b,f}\, m$

$\Pi = iMRT$

$P_{total} = P_A + P_B = X_AP_A° + X_BP_B°$

Acid Base:

$pH = -\log[H_3O^+]$

$pX = -\log X$

$$pH = pK_a + \log\frac{[A^-]}{[HA]}$$

Kinetics:

$[A]_t = [A]_0e^{-kt}$

$\ln[A]_t = \ln[A]_0 - kt$

$t_{1/2} = \ln 2/k$

$1/[A]_t = 1/[A]_0 + kt$

$k = A\, e^{(-Ea/RT)}$

$\ln(k_1/k_2) = E_a/R\, (1/T_2 - 1/T_1)$

$t_{1/2} = 1/[A]_0k$

$t_{1/2} = [A]_0/kt$

MULTIPLE CHOICE

For questions 1-3, complete the following table by filling in the numbered boxes. If an entry cannot be determined from the information given and the information on your periodic table, enter CBD (cannot be determined). Atomic masses are given in amu to three significant figures. Provide symbols as shown, using CBD if the complete symbol cannot be determined. Then answer the following multiple choice questions.

Symbol	Protons	Neutrons	Electrons	Charge	Mass
^{59}Co	27	(1)	27	(2)	(3)
(4)	6	(5)	6	0	(6)
(7)	(8)	2	2	-1	3.00

1.) What value should occupy box (1)? [HW B.11, C.7, C.9]

A) 28 B) 32 C) 44 D) 63 E) CBD

2.) What value should occupy box (5)? [HW B.11, C.7, C.9]

A) 2 B) 24 C) 12 D) 6 E) CBD

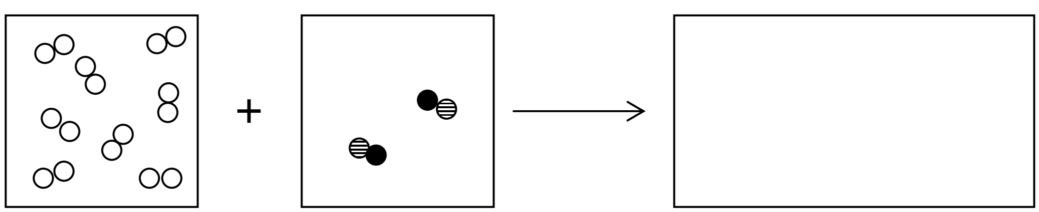
3.) What value should occupy box (7)? [HW B.11, C.7, C.9]

A) $^{1}H^{-1}$ B) $^{3}He^{-1}$ C) $^{3}H^{-1}$ D) $^{3}Li^{-1}$ E) CBD

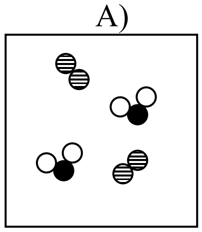
4.) A molecular picture for the reaction of H_2 and NO is shown below. Which of the diagrams (A-D) best represents the molecules after the reaction has taken place? [Discussion]

$$2H_2 + 2NO \rightarrow N_2 + 2H_2O$$

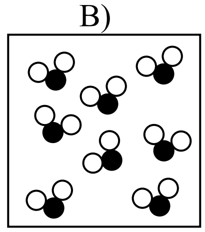
H= ○ N= ⊜ O= ●



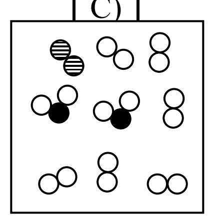
A)



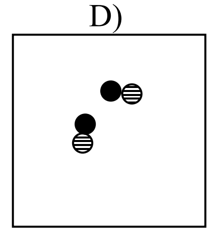
B)



C)



D)



For questions 5-8, consider 100 gram sample of an alloy (an alloy is a mixture, not a compound) discovered on earth as part of a small meteor believed to have originated on a distant planet. The alloy consists of approximately 50% copper, 26% aluminum, 20% titanium and 4.0% carbon by mass. There are also some trace (very small) amounts of other metals.

5.) What is the density (g/ml) of the alloy if immersing the sample in a graduated cylinder displaces 16.0 ml of water? [HW A.13]

A) $\boxed{6.3}$
B) 4.5
C) 1.1
D) 3.1
E) 8.2

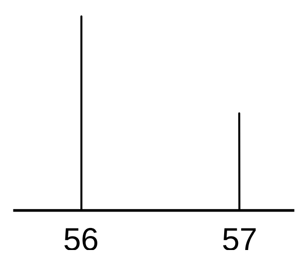
6.) What are the mole ratios of the compounds Cu:Al:Ti:C in the metal? [HW F.5, CQ MT1.1]

A) 1 : 2 : 1 : 3
B) 5.0 : 2.6 : 2.0 : 0.4
C) 0.85 : 0.77 : 0.22 : 0.01
D) $\boxed{0.79 : 0.96 : 0.42 : 0.33}$
E) 2 : 1 : 1 : 1

7.) How many atoms of carbon are in the sample? [HW B.1, E.11, E.19]

A) 6.0×10^{23}
B) 3.3×10^{18}
C) $\boxed{2.1 \times 10^{23}}$
D) 7.5×10^{23}
E) 9.1×10^{19}

8.) In the region of the mass spectrum of the alloy shown, evidence of elemental iron found. Estimate the relative molar mass of the iron as it is found on the meteor (and presumably on the planet of origin)? [HW E.6, CQ 2.1]



A) 55.84
B) 56.00
C) $\boxed{56.33}$
D) 56.75
E) 57.18

For questions 9 - 11, consider the plot of the variables described. If the plot is linear, give the slope of the line (h is Plank's constant). Answer 'non-linear' for other plots. [HW B.11, C.7, C.9]

9.) Atomic number vs. number of electrons for neutral elements.

A) 0 $\boxed{\text{B) 1}}$ C) 2 D) h E) non-linear

10.) Atomic number vs. number of neutrons for the elements.

A) 0 B) 1 C) 2 D) h $\boxed{\text{E) non-linear}}$

11.) Kinetic energy of emitted photoelectrons vs. Photon frequency.

A) 0 B) 1 C) 2 $\boxed{\text{D) h}}$ E) non-linear

For questions 12-14, consider a compound containing only carbon and hydrogen which is burned in pure oxygen. The mass spectrum of the products of the combustion is given below. Answer the following questions regarding the partially balanced chemical combustion reaction. [HW L.7, H.1, CQ 1.2, 2.2]

$$C_WH_X + Y\,O_2 \rightarrow 8\,CO_2 + Z\,H_2O$$

12.) What is the value of the subscript 'W' in the balanced combustion reaction?

A) 1 B) 3 $\boxed{\text{C) 8}}$ D) 12 E) 18

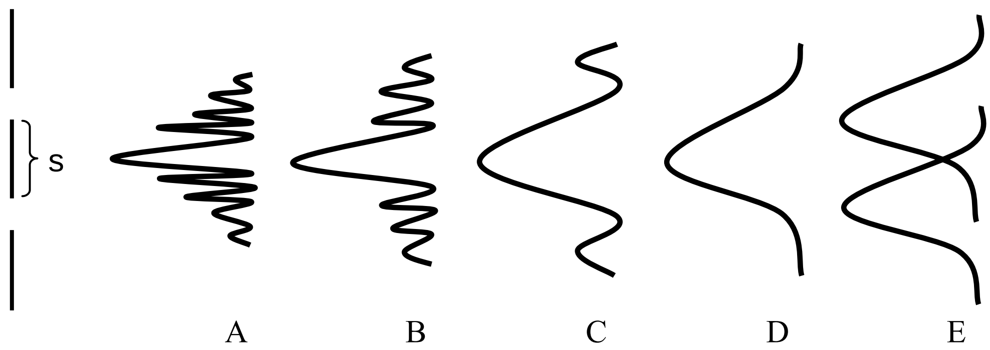
13.) What is the value of the coefficient 'Z' in the balanced combustion reaction?

A) 1 B) 3 $\boxed{\text{C) 8}}$ D) 12 E) 18

14.) What is the value of the coefficient 'Y' in the balanced combustion reaction?

A) 1 B) 3 C) 8 $\boxed{\text{D) 12}}$ E) 18

For questions 15 and 16, consider the following plots of potential two slit particle/wave patterns for the next questions. Assume plot 'B' is created by electrons traveling at 10^5 m/s and that the slit openings are wide enough to accommodate the particles discussed. [CQ 3.1, MT1.4]



15.) Which plot qualitatively depicts that formed by electrons traveling at 10^4 m/s?

A) A B) B $\boxed{\text{C) C}}$ D) D E) E

16.) Which plot qualitatively depicts that formed by neutrons traveling at 10^5 m/s ($m_n \sim 2000\ m_e$)?

$\boxed{\text{A) A}}$ B) B C) C D) D E) E

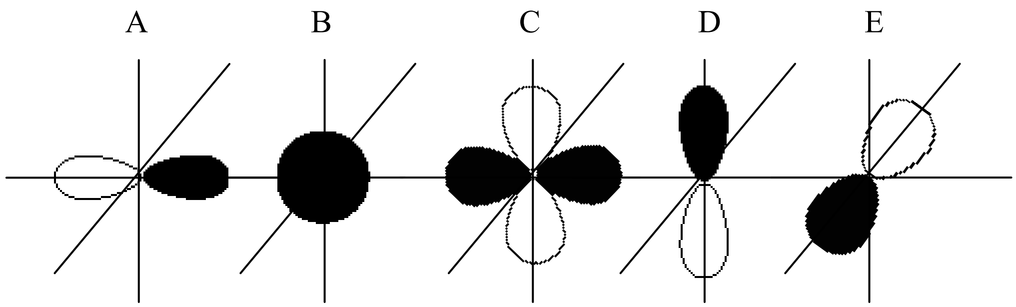
17.) Which excited state molecule or ion will have the smallest ionization energy? [HW 1.59, CQ 8.3, MT1.8]

A) $H(2p^1)$
B) $He(1s^13p^1)$
C) $Li(1s^24p^1)$
D) $Be(1s^22s^15p^1)$
E) $\boxed{B(1s^22s^26p^1)}$

18.) Which set of quantum numbers is not allowed?

A) $n = 1, \ell = 0, m_\ell = 0, m_s = ½$
B) $n = 3, \ell = 2, m_\ell = 1, m_s = ½$
C) $n = 2, \ell = 1, m_\ell = 0, m_s = -½$
D) $\boxed{n = 1, \ell = 0, m_\ell = 1, m_s = ½}$
E) $n = 4, \ell = 1, m_\ell = 1, m_s = ½$

For questions 19 - 21, consider the following set of five orbitals in which the dark areas represent a positive value of the wave function and the light represent a negative value of the wave function. [HW 1.31, MT1.6]



19.) How many nodes are displayed in orbital 'C'?

A) 0 B) 1 $\boxed{\text{C) 2}}$ D) 3 E) 4

20.) What is the best label for orbital 'E'?

A) 1s B) 2s $\boxed{\text{C) 2p}}$ D) 3s E) 3p

21.) Which orbital has the lowest energy?

A) A $\boxed{\text{B) B}}$ C) C D) D E) E

22.) Which orbital listed below has the greatest number of radial nodes? [HW 1.31, CQ 6.4]

A) 1s B) 2p $\boxed{\text{C) 3s}}$ D) 4d E) 5f

23.) Which neutral element has the ground state [Ar]$3d^3 4s^2$? [HW 1.67, CQ 7.4]

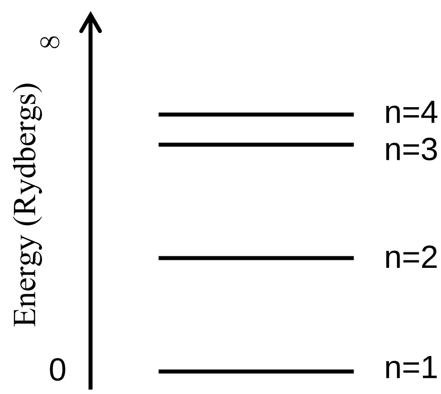
$\boxed{\text{A) V}}$ B) Zr D)Ti D) Fe E) Ta

24.) Which neutral, ground state atom is paramagnetic? [HW 1.73, CQ 7.3]

A) He B) Ar C) Ca D) Mg $\boxed{\text{E) C}}$

SHORT ANSWER

25.) (8 pt) The following plot of four electronic energy levels for a hydrogen atom has a few errors in one or more of the following subject areas: axes, units, spacing, scale, labels, or values. Identify at least two *different* scientific errors by filling in two different subject areas from the list above in the boxes provided. Describe the error and how to fix it in 15 WORDS OR LESS in the other boxes provided. [CQ 6.1, 6.2]



Subject Area: ***axis***	Description/Fix: ***0 energy should be at the top, bottom should be -∞***

Subject Area: ***spacing***	Description/Fix: *the spacing from n=2→3 should be smaller than n=1→2*

26.) (7 pts) In a combustion reaction, 44 g of propane (C_3H_8) burns in 160 g of oxygen (O_2) and yields 72 g of water (H_2O) and 132 g of carbon dioxide (CO_2). If the mass of propane is doubled, will more water be formed? Answer by filling in yes or no in the box provided, include a brief calculation to support your work and include an explanation in 15 WORDS OR LESS in the box provided (only the first 15 words will be considered in grading). [HW L.7, M.5, CQ 1.4]

Yes/No:

NO

Calculation:

$C_3H_8 + 5O_2 \rightarrow 4H_2O + 3CO_2$

original

44 g	160 g	72g	132g
1 mol	5mol	4mol	3 mol

doubling the propane would mean that twice as much O_2 (10 mol) is needed to produce any additional product, so 72 g of water will still be formed

Explanation:
the reactants are in stoichiometric mixture, so adding more propane would make O_2 the limiting reagent

27.) (7 pts) Indicate whether this statement is true or false, provide an equation or calculation and explain your reasoning in the following boxes (only the first 15 words will be considered for grading). [HW E.4, CQ 1.3, 1.4, Discussion]

"When carbon monoxide gas (CO) reacts with oxygen gas (O_2) to form carbon dioxide gas (CO_2) the total number of molecules present increases."

True False:

FALSE

Equation/Calculation:

$2CO$	+ O_2	$\rightarrow$	$2CO_2$
2mol	1mol		1 mol
2 molecules	1 molecule		2 molcule

Explanation:
in the balanced reaction 3 molecules combine to form 2 molecules

28.) (8 pts) The velocity of an electron that is emitted from a metallic surface by a photon is 3.6×10^6 m/s ($m_e = 9.10939 \times 10^{-31}$ kg). [HW 1.13, CQ 4.2, 4.3]

A) What is the wavelength (meters) of the ejected electron?

$\lambda_{deBroglie} = h / p = h / mv$
$=(6.62608\times10^{-34}Js)/(9.10939\times10^{-31}kg)(3.6\times10^{6}m/s)$
$=2.0\times10^{-10}m$

B) Does the ejected photoelectron exhibit quantized energy states? Explain in 15 words or less in the box provided.

Explanation:
No, a free electron is unbound and should behave classically

C) No electrons are emitted from the surface of the metal until the frequency of radiation reaches 2.5×10^{16} Hz. How much energy (joules) is required to remove the electron from the metal?

$E = h\nu$
$=(6.62608\times10^{-34}Js)(2.5 \times 10^{16} 1/sec)$
$=1.7\times10^{-17}J$