Chemistry 1A, Spring 2006

Midterm Exam I, Version 1

Feb 6, 2006

(90 min, closed book)

Name:_____

SID:_____

TA Name:_____

Identification Sticker

- Write your name on every page of this exam.
- This exam has 37 multiple choice questions. Fill in the Scantron form AND circle your answer on the exam.
- There is no penalty for guessing, so answer every question.
- Some questions may require bubbling in more than one choice to receive credit.

Name_____

$E = h\nu$

$\lambda\nu = c$

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

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...

$PV = nRT$

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

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

$\Delta E = q + w$

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

$$\Delta E = \frac{3}{2} nR\Delta T$$

$N_0 = 6.02214 \times 10^{23}$ 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}

Gas Constant:

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

R = 8.20578 x 10^{-2} L atm K^{-1} mol^{-1}

T (K) = T (C) + 273.15

F = 96,485 C / mol

1 V = 1 J / C 1 nm = 10^{-9} m

1 kJ = 1000 J

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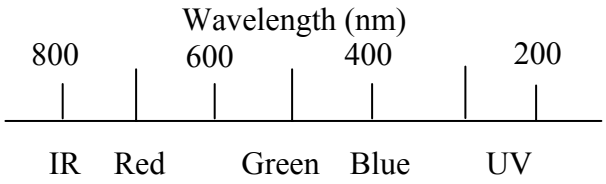
Color and Wavelength of Light



$\Delta G° = \Delta H° - T\Delta S°$

$\Delta H° = \Sigma \Delta H°_f$ (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)

$S = k_B \ln W$

for aA + bB $\rightleftharpoons$ cC + dD

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

$\Delta G° = - RT\ln K$

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

$\Delta G° = - nF\Delta Є°$

pX = - log X

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

Name_____

SECTION 1: ATOMS, MOLECULES AND MOLES

1.) What is the coefficient of oxygen in the balanced combustion reaction of one (1) mole of pentane (C_5H_{12})?

$$C_5H_{12} + O_2 \rightarrow CO_2 + H_2O$$

A) 1 B) 2 C) 4 D) 6 E) 8

2.) If one mole of pentane (C_5H_{12}) is burned in 7 moles O_2, which is true when the reaction goes to completion?

A) All the oxygen is consumed.
B) All the pentane is consumed.
C) No reagents remain.
D) An equal mass of each reagent remains.
E) None of these.

3.) How many moles of water are produced when 36.0 g of pentane are burned in excess oxygen?

A) 1.00 B) 2.24 C) 3.00 D) 4.75 E) 5.89

4.) How many moles of water are produced when 72.0 g of pentane are burned in 64.0 g oxygen?

A) 0.800 B) 1.50 C) 3.00 D) 6.00 E) 6.25

5.) Considering the relative atomic mass of oxygen to four significant figures is 16.00, what can be said about the relative natural abundance of the isotope ^{18}O?

A) It is present in about 50% natural abundance.
B) It is present in about 30% natural abundance.
C) It is present in about 10% natural abundance.
D) It is present in extremely low natural abundance.
E) It is present in extremely high natural abundance.

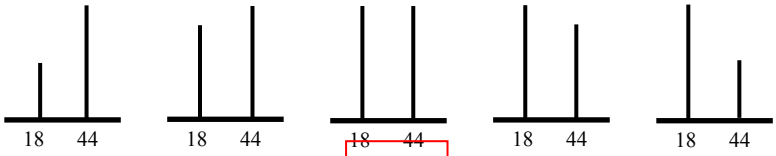
Name_____

For the next two questions (6,7) consider a gaseous hydrocarbon X which contains only carbon and hydrogen. It has a relative molar mass 2.625 times greater than molecular oxygen. One mole of hydrocarbon X requires 9.0 moles of molecular oxygen to react completely.

6.) What is the minimum mass (grams) of hydrocarbon X required to completely react with 4.0 g oxygen to produce carbon dioxide (CO_2) and water (H_2O)?

A) 0.24 B) 0.50 C) 1.2 D) 5.0 E) 8.6

7.) Which is the mass spectrum for the products of the combustion of hydrocarbon X?



A B C D E

8.) What is the molar mass (g/mol) of a sample of aluminum where all the atoms have 15 neutrons?

A) 13 B) 15 C) 28 D) 32 E) none of these

9.) How many protons are there in a cesium (Cs) nucleus?

A) 40 B) 55 C) 61 D) 79 E) 187

10.) What is the charge on a carbon (C) ion with 7 electrons?

A) -2 B) -1 C) 0 D) 1 E) 2

11.)Which of the following is an element?

A) air B) water C) uranium D) wine E) hydroxide

12.) How many moles of ethanol (C_2H_5OH) are contained in 12.0 mL pure ethanol (ethanol density: 0.90 g/mL)?

A) 0.14 B) 0.24 C) 0.55 D) 1.2 E) 37

Name_____

13.)Which atom has the smallest number of neutrons?

A) ^{27}Al B) ^{29}Si C) ^{32}S D) ^{32}P E) ^{35}Cl

14.)How many molecules of C_{60}, buckminsterfullerene, are formed when one mole of carbon atoms reacts to form C_{60} molecules?

A) 0 B) 1 C) 1.0×10^{22} D) 6.0×10^{23} E) 3.6×10^{25}

15.)Which is true of relative atomic masses

A) They are sufficient to identify an element.
B) They do not account for isotopes
C) They are determined relative to 12.00 grams of ^{12}C.
D) They are equal for all isotopes of an element.
E) both A and C are correct.

16.)Which is NOT true of elements which have radioactive isotopes?

A) They occur naturally.
B) Many are found in our food, making your body naturally radioactive.
C) They differ from the stable isotope in the number of protons in the nucleus.
D) They differ from the stable isotope in the number of neutrons in the nucleus.
E) They differ from the stable isotope in relative mass.

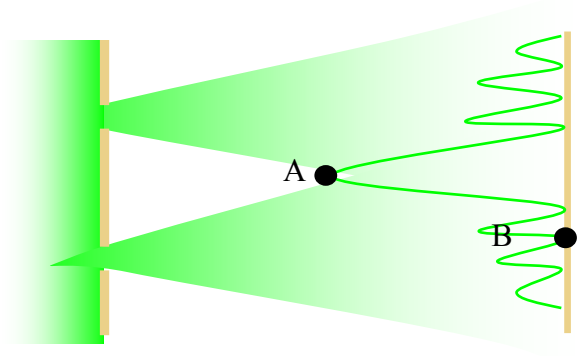
17.) What is the molar concentration (M) of an alcoholic beverage which is 12% ethanol (C_2H_5OH) by volume in water (ethanol density: 0.90 g/mL)?

A) 10 B) 5.5 C) 2.4 D) 0.12 E) 0.56

Name_____

SECTION 2: PROPERTIES OF PARTICLES AND LIGHT

Consider the two slit interference on a screen experiment shown below for the next four questions.



18.) Which is true around point A for an experiment with light (mark all that apply)?

A) Constructive interference occurs.
B) Destructive interference occurs.
C) The light on the screen is relatively bright.
D) The light on the screen is relatively dim.
E) None of these.

19.)Which is true around point B for an experiment with electrons (mark all that apply) ?

A) Constructive interference occurs.
B) Destructive interference occurs.
C) The probability of electron impact is high.
D) The probability of electron impact is low.
E) None of these.

20.)Which is true for a two slit experiment with golf balls (mass 70 g) (mark all that apply)?

A) Constructive interference occurs.
B) Destructive interference occurs.
C) The probability of golf balls impacts follows the light example.
D) The probability of golf balls impacts follows the electron example.
E) None of these.

21.)Which is true for an experiment with light of a shorter wavelength (with the same intensity. Mark all that apply)?

A) Photon frequencies decrease.
B) The distance between bright spots increases.
C) More photons strike the screen per second.
D) The amplitude of the wave pattern decreases.
E) None of these.

Consider the following list of particles for questions 22-24.

A) 450 nm photons.
B) Electrons traveling at around 10^5m/s.
C) Particles of sand (mass 0.01 g) in the wind traveling at around 30 m/s.
D) 170 g baseballs traveling at around 10 m/s.
E) 250 g soccer balls traveling at around 10 m/s.

22.) Which is the arrangement of the particles from smallest to largest de Broglie wavelength?

A) A,B,C,D,E
B) B,C,A,D,E
C) C,B,A,D,E
D) E,D,C,B,A
E) E,D,A,B,C

23.) For which particle can a 'two-slit' type interference pattern be obtained in practice?

A) A and B
B) A and C
C) B, C and D
D) D and E
E) All of the particles can display interference in practice.

24.) Which particles can have a 'zero-point' kinetic energy of zero?

A) A and B
B) A, B, and C
C) B, C and D
D) C, D and E
E) none of the particles have zero ground state energy.

25.) How many photons of 150 nm light are required to approximately stop a Na atom at a temperature of 60 K (de Broglie wavelength ~ 0.05 nm)?

A) 150 B) 1500 C) 3000 D) 5000 E) 1

26.) What is the designation for an orbital with five total nodes including one angular node?

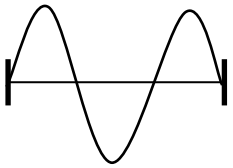
A) 5s B) 5p C) 6s D) 6p E) 7f

27.)Cupric sulfate solution is blue. Through a blue colored lens, what color will a cupric sulfate solution appear?

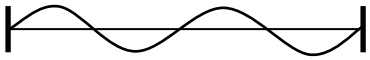
A) white B) black C) blue D) red E) green

Name_____

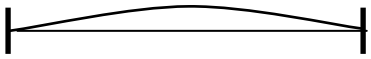
28.) Which wave form for a particle trapped in a 1-dimensional box has the lowest energy? Answer: E

A) 

B) 

C) 

D) 

E) 

29.) What is the length in meters of a one-dimensional box confining an electron if it requires a wavelength of 8080 nm to excite the electron from the n =1 to n=2 energy level?

A) 2.7×10^{-9}
B) 6.4×10^{5}
C) 7.1×10^{-8}
D) 2.2×10^{-4}
E) 3.9×10^{3}

For the remaining questions, consider that the work function of lithium metal (Li) is equal to 279 kJ/mol.

30.) What is the work function (J) per electron?

A) 1.5×10^{-23}
B) 9.8×10^{-18}
C) 4.9×10^{22}
D) 4.6×10^{-19}
E) 8.5×10^{-20}

31.) What is the work function per electron when expressed as a frequency (Hz)?

A) 6.1×10^{10}
B) 7.0×10^{14}
C) 9.6×10^{9}
D) 6.3×10^{12}
E) 4.3×10^{17}

Name_____

32.) What is the lowest frequency radiation sufficient to eject a photoelectron from lithium metal?

A) 6.1×10^{10}
B) 7.0×10^{14}
C) 9.6×10^{9}
D) 6.3×10^{12}
E) 4.3×10^{17}

33.) What is the longest wavelength radiation (nm) capable of ejecting a photoelectron from lithium metal?

A) 530
B) 430
C) 230
D) 3700
E) 4300

34.) Will visible red light eject an electron from lithium metal?

A) Yes
B) No
C) Depends

35.) What is the best explanation for the interaction of the red light and lithium metal?

A) Electrons are not ejected, the photon energy is not great enough.
B) Electrons are ejected the photon energy is great enough.
C) Electrons may be ejected if the intensity of the light is great enough.
D) The work function is not sufficient to maintain electrons on the metal.
E) Electrons can be ejected at any non-zero intensity.

36.) How many photoelectrons are ejected per second from lithium metal by light of wavelength $\lambda = 400$ nm (1 nm = 10^{-9} m) that delivers 2.2×10^{-16} W (1 W = 1 watt = 1 J/s)?

A) 1200
B) 100
C) 480
D) 5500
E) 67000

37.) What features describe the plot of kinetic energy of electrons ejected from lithium metal (y axis) as a function of radiation frequency (x axis) (mark all that apply)?

A) The plot is linear.
B) The plot has a slope equal to Planks constant.
C) The plot has a negative slope.
D) A point (w, 0) falls on the plot where w is the work function in Hz.
E) The plot is non linear when frequency exceeds the work function.