Chemistry 1A, Fall 2002

Midterm Exam I, Version A

September 17, 2002

(90 min, closed book)

Name:_________________________ **TA:**_________

SID:___________________________ **Section:**_____

Please read this first: Write your name and that of your TA on all 9 pages; On the **Scantron™**, bubble in Form A.

Test-taking Strategy

This test consists of two parts: multiple choice (**answers to be circled and entered on the Scantron™ sheet**) and short answer. In order to maximize your score on the exam:

- Do the questions you know how to do first.
- Then, go back and spend more time on the questions you find more challenging.
- Budget your time carefully -- don't spend too much time on one problem.

- Show all work for which you want credit and don't forget to include units.

Page	Score
MC	
7	
8	
9	
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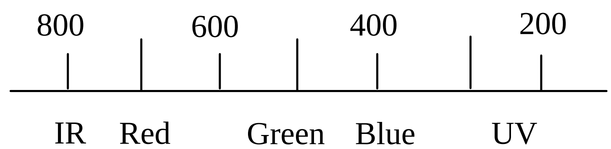
Potentially Useful Information

$E = h\nu$
$\lambda\nu = c$
$\lambda_{\text{deBroglie}} = h / p = h / mv$
$E_{kin}\text{(e-)} = h\nu - \Phi = h\nu - h\nu_0$
$E_n = -\dfrac{Z^2}{n^2} R_\infty$
$E_{kin} = \tfrac{1}{2} mv^2$

$h = 6.626 \times 10^{-34}$ J s
$c = 3.0 \times 10^{8}$ m·s^{-1}
$R_\infty = 2.18 \times 10^{-18}$ J
$m_e = 9.11 \times 10^{-31}$ kg
1 eV = 1.602×10^{-19} J
1 nm = 10^{-9} m
1 kJ = 1000 J

Color and Wavelength of Light



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Part I Multiple Choice (4 pts each, 88 pts total) Bubble in the correct answer on your Scantron™ form AND circle your answer on the exam. There is only one correct answer for each question, so you should circle and fill in one and only one answer for each question. There is no penalty for an incorrect response.

1.) Which neutral atom could have the configuration $1s^2 2s^2 2p^6 3s^2 3p^4 4s^1$?

A) K   B) Cl   C) Na   D) Rb   E) S

2.) What mass (in kg) of water (H_2O) has the same number of molecules as 1.0 kg of acetylene (C_2H_2)?

A) 0.69   B) 0.10   C) 18   D) 26   E) 200

3.) What is the molar concentration (mol/L) of oxygen (O_2) when 320 grams of oxygen gas are dissolved in 2.00 L of water?

A) 0.02   B) 3.3   C) 2.0   D) 0.77   E) 5.0

4.) Which of the following is a valid set of quantum numbers for an electron in a 3d orbital?

A) $n=3, \lambda=2, m_\lambda=0$
B) $n=3, \lambda=3, m_\lambda=3$
C) $n=2, \lambda=3, m_\lambda=1$
D) $n=3, \lambda=1, m_\lambda=-1$
E) $n=3, \lambda=2, m_\lambda=3$

5.) Which species has eight protons, eight electrons, and ten neutrons?

A) ^{18}O B) ^{16}O C) ^{10}Ne D) ^{20}Ne E) ^{8}O

6.) Which best describes the $^{56}Fe^{2+}$ ion?

A) 56 protons, 56 neutrons, and 56 electrons
B) 56 protons, 56 neutrons, and 2 electrons
C) 26 protons, 30 neutrons, and 24 electrons
D) 26 protons, 30 neutrons, and 26 electrons
E) 28 protons, 28 neutrons, and 26 electrons

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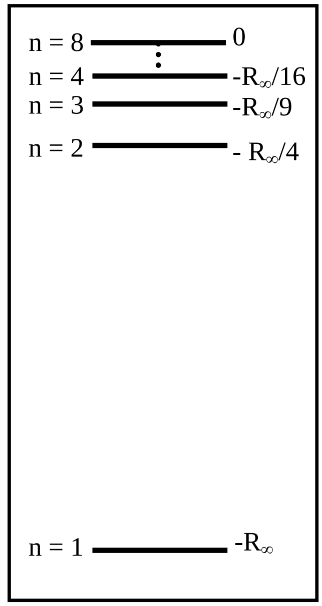
7.) What wavelength of light (in nm) is emitted by a hydrogen atom that undergoes a transition from n=4 to n=1?

A) $\boxed{97}$
B) 365
C) 823
D) 1460
E) 240



8.) Will a photon with an energy of ½R be absorbed by the hydrogen atom?

A) yes
B) $\boxed{\text{no}}$
C) if one mole of photons is provided.
D) if the frequency is high enough.
E) not enough information.

9.) A sample of 0.245 moles of solid gold (Au) is dropped into a graduated cylinder, causing the water (H_2O) level to rise from 10.4 mL to approximately 12.9 mL. What is the density of gold (in g/mL)?

A) 2.50 B) 0.245 C) 3.74 D) 0.018 E) $\boxed{19.3}$

10.) How much energy is required (in joules) to ionize the hydrogen atom?

A) 3.3×10^{-15}
B) $\boxed{2.2 \times 10^{-18}}$
C) 6.6×10^{-10}
D) 2.1×10^{-17}
E) 4.3×10^{-20}

11.) What is the energy in joules of one mole of photons of wavelength 656 nm?

A) 2.84×10^{-19}
B) 4.29×10^{14}
C) $\boxed{1.82 \times 10^{5}}$
D) 7.41×10^{10}
E) 2.79×10^{-16}

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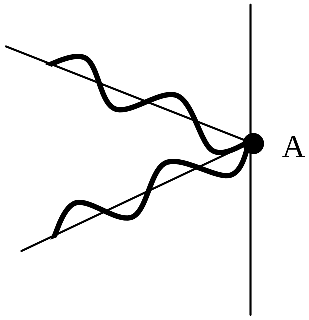
12.)What is the result on the screen at point A when the following two light waves meet?



A) a longer wavelength (color)
B) a shorter frequency (lower energy)
$\boxed{\text{C) a bright spot}}$
D) a dark spot
E) alternating dark and bright spot

13.)Which of the following has the longest de Broglie wavelength when all are traveling at the same velocity?

A) bowling ball (2 kg)
B) golf ball (50 g)
C) $\boxed{\text{ping pong ball (3 g)}}$
D) baseball (105 g)
E) basketball (1500 g)

14.)What wavelength of light (in nm) will eject an electron with a velocity of 2.7×10^5 m s^{-1} from chromium (the work function for chromium metal is 4.37 eV)?

A) 60 B) 76 C) 84 D) 110 E) $\boxed{271}$

15.)Acetylene (C_2H_2) burns in excess oxygen (O_2) according to the reaction
_C_2H_2 + _O_2 $\rightarrow$_CO_2 + _H_2O. What is the coefficient for O_2 when the acetylene coefficient is 2?

A) 2 B) 3 C) 4 D) $\boxed{5}$ E) 6

16.)Two compounds, 26 grams of acetylene (C_2H_2) gas and 320 grams of oxygen (O_2) gas, are held in separate balloons, what is the ratio of the volume of the acetylene balloon to the oxygen balloon?

A) 1:1 B) 1:2 C) 1:5 D) $\boxed{1:10}$ E) 2:1

17.)How many grams of water are formed when a 26 gram sample of acetylene (C_2H_2) burns in 320 grams of oxygen (O_2)?

A) 5 B) 10 C) $\boxed{18}$ D) 20 E) 7

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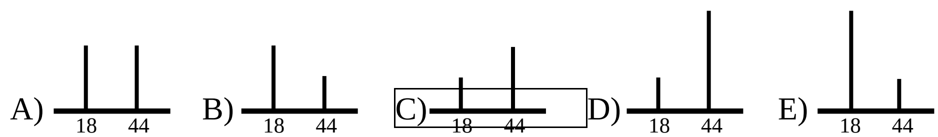
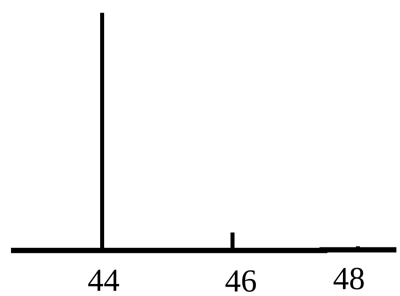
18.) What is the relationship between the masses of the remaining compounds after 26 grams of C_2H_2 gas reacts with 320 grams of oxygen to form CO_2 and H_2O?

A) $CO_2 = O_2 = H_2O$
B) $\boxed{O_2 > CO_2 > H_2O}$
C) $H_2O > O_2 > CO_2$
D) $H_2O > CO_2 > O_2$
E) $H_2O > CO_2 = O_2$

19.) Which would be the mass spectrum of the products when acetylene (C_2H_2) is burned in oxygen?



20.) An expansion of the mass spectral region around 44 mass units for the products of acetylene combustion in oxygen shows the following. What is the likely explanation of the peak at mass number 46?



A) Presence of ^{13}C in acetylene burned.
B) Presence of ^{18}O in the water formed.
C) Presence of ^{18}O in oxygen burned.
D) Presence of ^{2}H in the water formed.
E) None of these.

21.) What is the maximum number of electrons with the same spin quantum number (m_s) for the principle quantum number 3?

A) 4 B) 8 C) $\boxed{9}$ D) 14 E) 19

22.) Which of the following electronic configurations is not possible?

A) $1s^22s^22p^53s^1$
B) $1s^22s^12p^6$
C) $1s^22s^22p^63s^1$
D) $\boxed{1s^22s^22p^73s^1}$
E) none of the above

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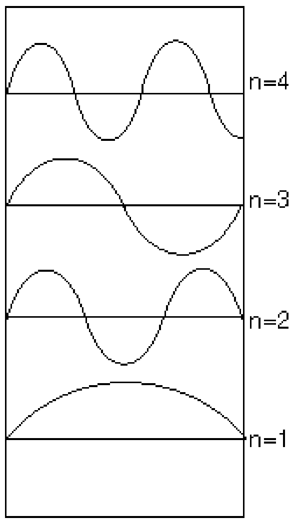
Part 2: Short Answer Problems (62 pts total)
Instructions: Enter answers in the boxes where provided. Show all work for which you wish to receive credit. Where explanations are required, only the first fifteen words will be considered for your grade.

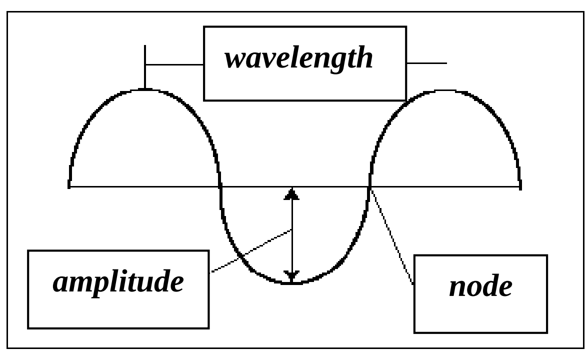
1) a) The picture on the left shows the first four one-dimensional wave functions. Identify and explain two errors that exist in this picture.



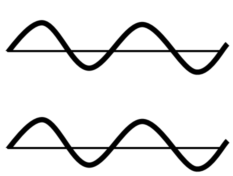
Error 1)
the wave functions for n = 3 and n = 2 are reversed in the diagram
***** Also accepted as the <u>two</u> errors total*****

Error 2)
the wave function shown for n = 4 is not valid
-it is not a standing wave
-it should have two complete wavelengths
-the ends of the wave function should end at the origin (zero)

b) Label in words the features of the waveform by filling in the boxes drawn below.



c) What is the result of when these two standing waves occupy the same box? (Circle the correct answer)



$\boxed{\text{A) constructive interference}}$
B) destructive interference
C) zero amplitude
D) an increase in the number of nodes
E) a mixture of constructive and destructive interference.

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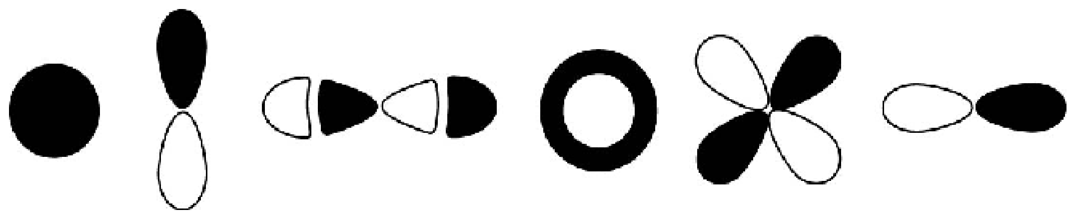
2.) Fill in the table below for each of the orbitals shown:
Black shading indicates a positive sign of the wave function and white shading indicates a negative sign.



n	1	***2***	***3***	2	***3***	***2***
λ	***0***	***1***	1	***0***	***2***	***1***
type of orbital	***s***	***p***	***p***	***s***	***d***	p
number of angular nodes	***0***	1	***1***	***0***	***2***	***1***
number of radial nodes	***0***	***0***	***1***	***1***	0	***0***

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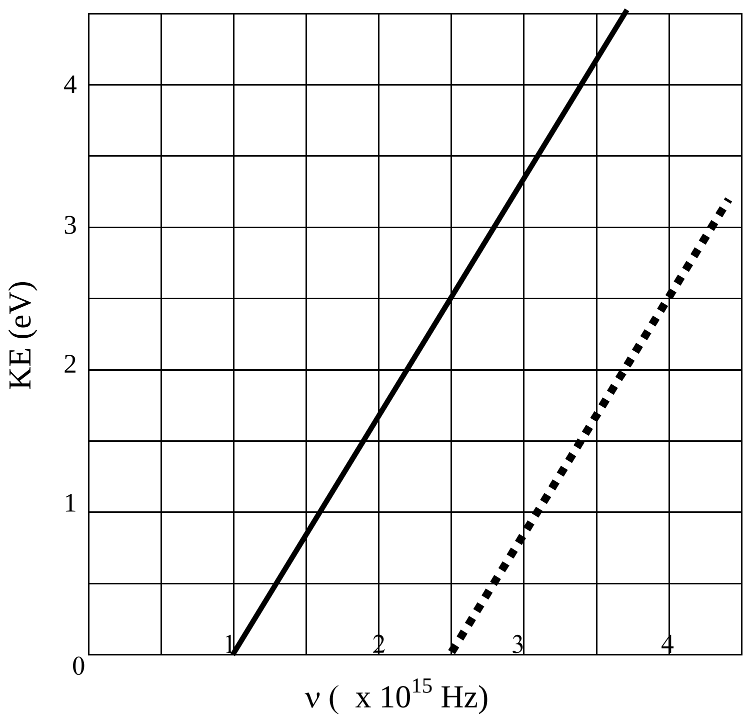
3) In an “alternate universe” two metals, A and B, are used to investigate the photoelectric effect.



The plot is the energy of photoelectrons emitted from metal A vs. photon frequency.

a) What is meaning of the x-intercept for the plot?

Answer:

The x-intercept is the minimum frequency of light needed to eject an electron for metal A.

b) If light of 2.5 x 10^{15} Hz is the minimum frequency required to eject electrons from metal B, draw the dependence of kinetic energy on frequency on the graph above.

see dotted line above

correct slope 3 points

correct intercept 3 points

c) Which of the following is the correct value of h (in J s) for the “alternate universe” depicted in the above graph? (Circle the correct answer)

$$E_{kin}\ (e\text{-}) = h\nu - \Phi \qquad y = mx + b \qquad \text{slope} = h$$

$$h = \frac{\Delta y}{\Delta x} = \frac{(2.5 - 0)\ \text{eV}}{(2.5 - 1.0) \times 10^{15}\ \text{Hz}}$$

$$\text{Hz} = \frac{1}{\text{sec}} \quad \text{so,} \quad h = \frac{2.5\ \text{eV} \cdot \text{sec}}{1.5 \times 10^{15}} = 1.67 \times 10^{-15}\ \text{eV} \cdot \text{sec}$$

$$h = 1.67 \times 10^{-15}\ \text{eV} \cdot \text{sec} \times \frac{1.602 \times 10^{-19}\ \text{J}}{1\text{eV}} = 2.67 \times 10^{-34}\ \text{J} \cdot \text{sec}$$