Chemistry 1A

Midterm Exam #1

Tuesday, September 18, 2018

Name: ______________________________

SID: ____________________________________

GSI Name: _______________________________

Write your name on all the pages of the exam.

For multiple choice questions, fill in the bubble (◯) completely.

Multiple choice questions have only one correct answer.

For short-answer questions, answers outside the boxes provided will not be graded.

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Potentially helpful equations and fundamental constants:

$$\Delta E = E_{\text{photon}}$$

$$E_{\text{photon}} = \Phi + K$$

$$K = \frac{1}{2}mv^2$$

$$E = h\upsilon$$

$$-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}\psi(x) + V(x)\psi(x) = E\psi(x)$$

$$\lambda = \frac{h}{mv} = \frac{h}{p}$$

$$K \approx \frac{h^2}{2m\lambda^2}$$

$$E = -\frac{Ry}{n^2}Z^2$$

$$\ell = 0(s), 1(p), \dots, n-1$$

$$m = -\ell, \dots, 0, \dots, \ell$$

$$m_s = \pm\frac{1}{2}$$

$$1\text{Å} = 10^{-10}\, m = 0.1\, nm$$

$$\frac{10^{24}¢}{10^{10}\text{ people}} = \text{a trillion bucks per person}$$

$$1\text{ amu} = 1\frac{g}{\text{mol}}$$

$$\#\text{ grains of sand on earth} \approx 10^{18}$$

$$V = -\frac{k_C e^2}{R}$$

$$k_C = \frac{1}{4\pi\varepsilon_0} \approx 9.9 \times 10^9 \frac{J \cdot m}{C^2}$$

$$\hbar = \frac{h}{2\pi}$$

$$a_0 = \frac{\hbar^2}{k_C m_e e^2} \approx 0.5\text{ Å}$$

$$\#\text{ nodes} = n - 1$$

$$\#\text{ angular nodes} = \ell$$

$$[\text{Ne}] = 1s^2\, 2s^2\, 2p^6$$

$$hc = 1.2 \times 10^5 nm \frac{kJ}{\text{mol}}$$

$$c = \lambda\upsilon$$

$$N_A \approx 6 \times 10^{23}$$

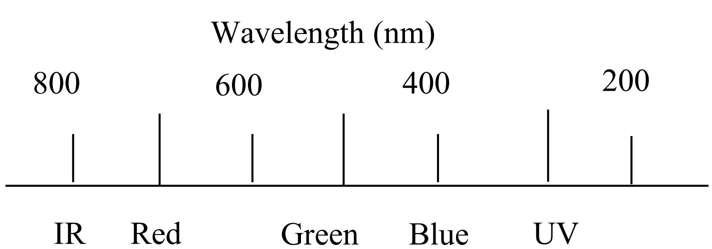
$$Ry \approx 2 \times 10^{-18} J \approx 1300 \frac{kJ}{\text{mol}}$$

$$h \approx 6.6 \times 10^{-34} J \cdot s$$

$$m_e \approx 9 \times 10^{-31} kg$$

$$c \approx 3 \times 10^8 \frac{m}{s}$$

Color and Wavelength of Light



THE PERIODIC TABLE

H — SYMBOL
1 — ATOMIC NUMBER
1.008 — ATOMIC WEIGHT
Hydrogen — NAME

( ) = ESTIMATES

METAL
METALLOID
NONMETAL

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
H 1 1.01 Hydrogen																	He 2 4.00 Helium
Li 3 6.94 Lithium	Be 4 9.01 Beryllium											B 5 10.81 Boron	C 6 12.01 Carbon	N 7 14.01 Nitrogen	O 8 16.00 Oxygen	F 9 19.00 Fluorine	Ne 10 20.18 Neon
Na 11 22.99 Sodium	Mg 12 24.31 Magnesium											Al 13 26.98 Aluminum	Si 14 28.09 Silicon	P 15 30.97 Phosphorus	S 16 32.07 Sulfur	Cl 17 35.45 Chlorine	Ar 18 39.95 Argon
K 19 39.10 Potassium	Ca 20 40.08 Calcium	Sc 21 44.96 Scandium	Ti 22 47.88 Titanium	V 23 50.94 Vanadium	Cr 24 52.00 Chromium	Mn 25 54.94 Manganese	Fe 26 55.85 Iron	Co 27 58.93 Cobalt	Ni 28 58.69 Nickel	Cu 29 63.55 Copper	Zn 30 65.39 Zinc	Ga 31 69.72 Gallium	Ge 32 72.61 Germanium	As 33 74.92 Arsenic	Se 34 78.96 Selenium	Br 35 79.90 Bromine	Kr 36 83.80 Krypton
Rb 37 85.47 Rubidium	Sr 38 87.62 Strontium	Y 39 88.91 Yttrium	Zr 40 91.22 Zirconium	Nb 41 92.91 Niobium	Mo 42 95.94 Molybdenum	Tc 43 (97.9) Technetium	Ru 44 101.07 Ruthenium	Rh 45 102.91 Rhodium	Pd 46 106.42 Palladium	Ag 47 107.87 Silver	Cd 48 112.41 Cadmium	In 49 114.82 Indium	Sn 50 118.71 Tin	Sb 51 121.76 Antimony	Te 52 127.60 Tellurium	I 53 126.90 Iodine	Xe 54 131.29 Xenon
Cs 55 132.91 Cesium	Ba 56 137.33 Barium	La 57 138.91 Lanthanum	Hf 72 178.49 Hafnium	Ta 73 180.95 Tantalum	W 74 183.85 Tungsten	Re 75 186.21 Rhenium	Os 76 190.2 Osmium	Ir 77 192.22 Iridium	Pt 78 195.08 Platinum	Au 79 197.97 Gold	Hg 80 200.59 Mercury	Tl 81 204.38 Thallium	Pb 82 207.2 Lead	Bi 83 208.98 Bismuth	Po 84 (209) Polonium	At 85 (210) Astatine	Rn 86 (222) Radon
Fr 87 223.02 Francium	Ra 88 226.03 Radium	Ac 89 227.03 Actinium	Rf 104 (261) Rutherfordium	Db 105 (262) Dubnium	Sg 106 (263) Seaborgium	Bh 107 (262) Bohrium	Hs 108 (265) Hassium	Mt 109 (266) Meitnerium	Unnamed Discovery 110 Nov. 1994	Unnamed Discovery 111 Nov. 1994	Unnamed Discovery 112 1996		Unnamed Discovery 114 1999		Unnamed Discovery 116 1999		Unnamed Discovery 118 1999
ALKALI METALS	ALKALI EARTH METALS															HALOGENS	NOBLE GASES

LANTHANIDES	Ce 58 140.12 Cerium	Pr 59 140.91 Praseodymium	Nd 60 144.24 Neodymium	Pm 61 (145) Promethium	Sm 62 150.36 Samarium	Eu 63 152.97 Europium	Gd 64 157.25 Gadolinium	Tb 65 158.93 Terbium	Dy 66 162.50 Dysprosium	Ho 67 164.93 Holmium	Er 68 167.26 Erbium	Tm 69 168.93 Thulium	Yb 70 173.04 Ytterbium	Lu 71 174.97 Lutetium
ACTINIDES	Th 90 232.04 Thorium	Pa 91 231.04 Protactinium	U 92 238.03 Uranium	Np 93 237.05 Neptunium	Pu 94 (240) Plutonium	Am 95 243.06 Americium	Cm 96 (247) Curium	Bk 97 (248) Berkelium	Cf 98 (251) Californium	Es 99 252.08 Einsteinium	Fm 100 257.10 Fermium	Md 101 (257) Mendelevium	No 102 259.10 Nobelium	Lr 103 262.11 Lawrencium

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1) Light irradiates a metal surface and ejects an electron. Compare the energy E_{photon} of the incoming photon to the kinetic energy $K_{electron}$ of the ejected electron.

- ○ $E_{photon} > K_{electron}$
- ○ $E_{photon} = K_{electron}$
- ○ $E_{photon} < K_{electron}$
- ○ Not enough information

2) A compound strongly absorbs light between 300-650 nm. Light is transmitted between 650 -750 nm. What color is the compound?

- ○ Blue
- ○ Green
- ○ Yellow
- ○ Red

3) Rank the following objects in order of their de Broglie wavelength (smallest to greatest).

- ○ 3 m/s baseball < 30 m/s baseball < 10^2 m/s electron < 10^4 m/s electron
- ○ 30 m/s baseball < 3 m/s baseball < 10^4 m/s electron < 10^2 m/s electron
- ○ 10^2 m/s electron < 10^4 m/s electron < 3 m/s baseball < 30 m/s baseball
- ○ 3 m/s baseball < 10^2 m/s electron < 30 m/s baseball < 10^4 m/s electron

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4) Ozone molecules (O_3) can react with oxygen atoms (O) to produce diatomic oxygen (O_2).

i. Write a balanced reaction equation for this process.

The destruction of ozone is much more rapid in the presence of chlorine atoms, through a sequence of reactions

$$\mathrm{Cl} + \mathrm{O_3} \rightarrow \mathrm{ClO} + \mathrm{O_2}$$
$$\mathrm{ClO} + \mathrm{O} \rightarrow \mathrm{Cl} + \mathrm{O_2}$$

Consider a mixture that initially contains no O_2, no ClO, and the following masses of Cl, O_3, and O:

18 g Cl

48 g O_3

32 g O

ii. How many moles of Cl, O_3, and O are initially present? (Only one significant figure is needed for each species.)

Final Answer

_____________ Cl

____________ O_3

_____________ O

Name___________________________ SID__________________

iii. How many oxygen nuclei are initially present? (Your answer should be a number with no units.)

_______________ Final Answer

iv. If the sequence of reactions proceeds as far as possible, which molecule or atom is the limiting reagent? Explain your reasoning.

v. What is the system's total mass at the end of the reaction?

_______________ Final Answer

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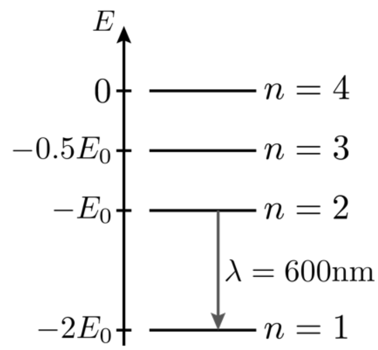
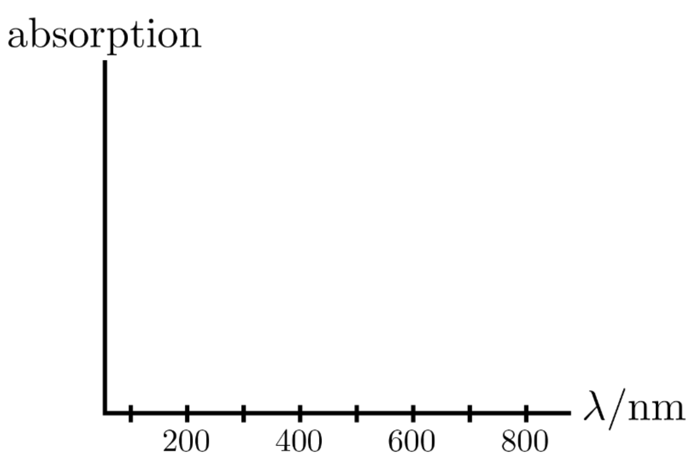
5) The diagram below shows the allowed energy levels of a certain molecule.



i. A transition from $n = 2$ to $n = 1$ is accompanied by emission of a photon with wavelength $\lambda = 600$ nm, as shown in the energy level diagram. Using this information, calculate the value of E_0 in units of kJ/mol.

_______________ Final Answer

ii. When the molecule is in its ground state ($n = 1$), only certain colors of light can be absorbed. On the graph below sketch its absorption spectrum as a function of wavelength λ. Consider only transitions that begin from $n = 1$.



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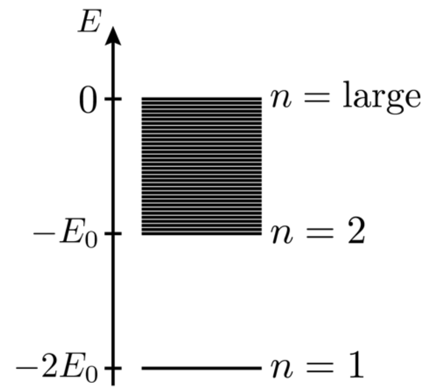
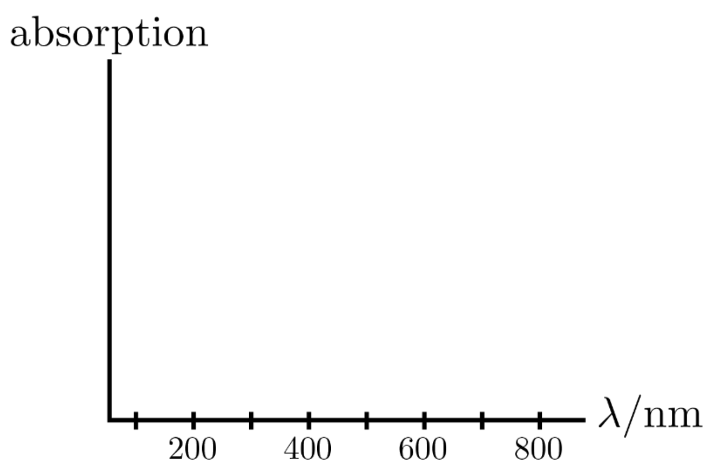
iii. A different substance has many more energy levels in the range between $E = -E_0$ and $E = 0$, as shown below.



Considering only transitions that begin from $n = 1$, sketch the absorption spectrum of this substance on the graph below. (You may assume that excited states are so numerous that the spectrum is very smooth.)



iv. Based on the absorption spectrum you drew in part (iii), describe the appearance of this substance to the eye.

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6) Consider an electron in a potential energy $V(x)$ described by 4 different wavefunctions as shown in panels (a), (b), (c), and (d):

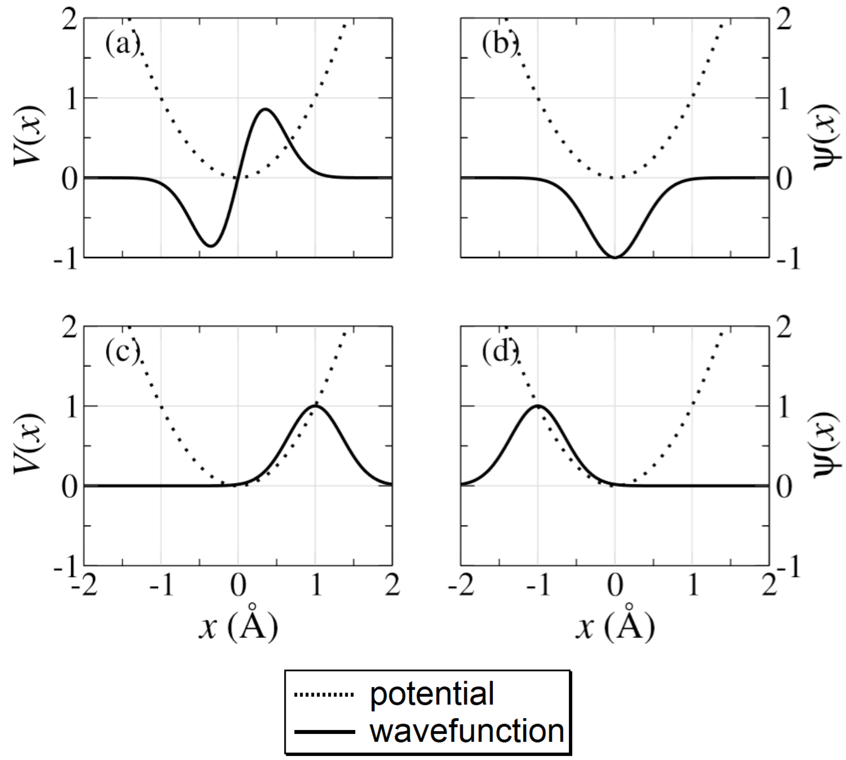

Figure 1: The potential energy ($V(x)$) is shown by the dotted curve and the electron wavefunction ($\psi(x)$) by the solid curve.

i. For each panel (b), (c), and (d) in Figure 1, where on the x-axis is the most probable location to find the electron? Explain your answer.

ii. Which wavefunction (or wavefunctions) has the highest kinetic energy? Please reason your answer.

iii. Which wavefunction (or wavefunctions) has the lowest kinetic energy? Please reason your answer.

iv. Which wavefunction (or wavefunctions) has the highest potential energy? Please reason your answer.

v. Which wavefunction (or wavefunctions) has the lowest potential energy? Please reason your answer.

vi. True or false: For panel (a) in Figure 1, the probability of finding the electron in $x < 0$ is smaller than the probability of finding the electron in $x > 0$ because the wavefunction for $x < 0$ is negative. Explain your answer.

◯ True ◯ False	Explain: