Midterm 1
February 7, 2011
(90 min, closed book)

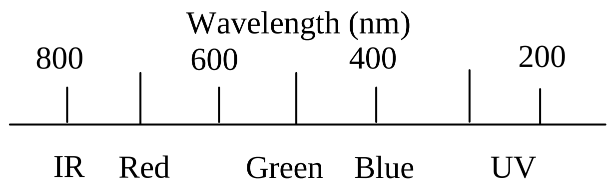
Name:___________________

SID:_____________________

TA Name:________________

- There are 40 multiple choice questions worth 3 points each.
- There is only one correct answer for each question unless otherwise specified in the question.
- Only answers on the Scantron form will be graded.
- The exam question sheets will NOT be collected.
- Use the back side and page margins as scratch paper.
- The periodic table can be torn off.

Color and Wavelength of Light



Quantum:

$E = h\nu$

$\lambda\nu = c$

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

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

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

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

$p = mv$

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

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

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

$m = m_A m_B/(m_A + m_B)$

Ideal Gas:

$PV = nRT$

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

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

Constants:

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

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

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

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

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

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

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

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:

$\Delta G° = \Delta H° - T\Delta S°$

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

$\Delta S° = \sum S°$ (products) $- \sum S°$ (reactants)

$\Delta G° = \sum \Delta G°_f$ (products) $- \sum \Delta G°_f$ (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 $\gamma[A]/[A]°$

$\Delta G° = - RT\ln K$

$\Delta G° = - nF\Delta Є°$

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

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

$\Delta T = i k_{b,f}\, m$

$\Pi = iMRT$

$P_{total} = P_A + P_B = X_A P_A° + X_B P_B°$

Acid Base:

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

$pX = - \log X$

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

Kinetics:

$[A]_t = [A]_0 e^{-kt}$

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

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

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

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

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

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

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

SECTION 1: ATOMS, MOLECULES AND MOLES

1. The complete combustion of liquid propyl alcohol (C_3H_7OH) in oxygen yields just carbon dioxide and water. When this reaction is balanced using smallest integer coefficients, the coefficient for O_2 is
A. 5
B. 9
C. 10
D. 20
E. none of these
ANS: B

2. The ratio of the number of bismuth atoms to the number of oxygen atoms in $Bi_2(SO_4)_3$ is
A. 1:6
B. 2:7
C. 2:3
D. 2:1
E. none of these
ANS: A

3. A ternary compound contains one atom of scandium and three atoms of nitrogen for every nine atoms of oxygen. A possible formula for the compound is
A. $Sc(NO_3)_3$
B. $Sc_2(N_2O_3)_3$
C. $Sc(NO_2)_4$
D. $Sc(NO_4)_3$
E. none of these
ANS: A

4. Assume that the following reaction between phosphorus and chlorine gas goes as far as possible to give the product, gaseous phosphorus pentachloride.

$P_4(s) + 10\ Cl_2(g) \rightarrow 4\ PCl_5(g)$

If 0.231 mol of P_4 is reacted with an excess of Cl_2, how much PCl_5 will be produced?
A. 0.231 mol
B. 0.462 mol
C. 0.693 mol
D. 0.924 mol
E. none of these
ANS: D

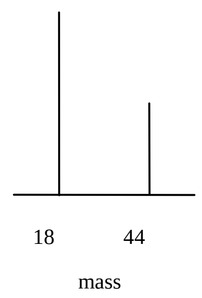
5. An unknown mass of element A reacts with 1.811 g of element B and 3.613 g of element C to produce 7.124 g of a compound containing A, B, and C. Assuming all reactants are consumed, what additional information is required in order to calculate the unknown mass of A?
A. a balanced equation for the reaction
B. the molar masses of A, B and C
C. the formula of the reaction product
D. All of the above are required.
E. None of the above is required.
ANS: E

6. The mass number of an atom indicates
A. the number of electrons in the atom.
B. the number of protons in the atom.
C. the number of neutrons in the atom.
D. the sum of the numbers of protons and electrons in the atom.
E. the sum of the numbers of neutrons, protons and electrons in the atom.
ANS: E
EVERYONE was credited 3 points for this question regardless of the answer.
There is a severe omission/simplification in the TRO 2nd ed. textbook. On page 56 it states correctly that A= number of protons (p) + neutrons (n). A is called the nucleon number or the number of nucleons, it is not the atomic mass at all. The atomic mass is the mass of the nucleons plus the mass of the electrons. That is why A is always s a whole number, whereas the atomic mass will not be an integer value, but a non-integer value. I will contact Professor Tro and the Mastering Chemistry staff to have this corrected in the next edition of the book.

7. How many electrons does the species $^{57}Fe^{3+}$ have?
A. 23
B. 26
C. 29
D. 54
E. none of these
ANS: A

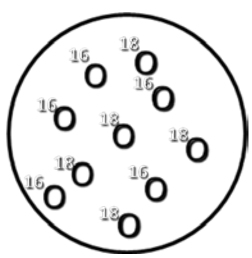
8. A single atom of an unknown element has a mass of 2.339824×10^{-22} g. Assuming that the element has only one naturally occurring isotope, the element must be
A. La
B. Ce
C. Pr
D. Nd
E. none of these
ANS: C

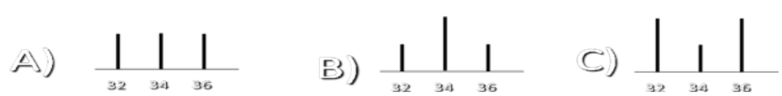
9. The combustion products of a hydrocarbon with which empirical formula yield the following mass spectrum?



A. C_4H
B. C_2H
C. CH
D. CH_2
E. CH_4
ANS: E

10. An equimolar mixture of oxygen atomic isotopes forms oxygen molecules. Which is the correct O_2 spectrum?



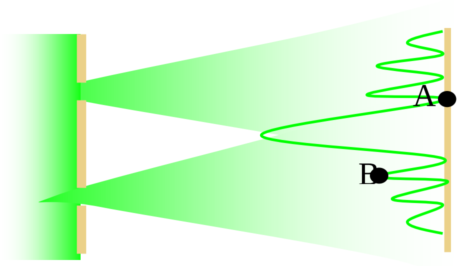


ANS: B

11. The empirical formula for a hydrocarbon is found to be CH_2. In a separate experiment, the molar mass is determined to be approximately 112 g mol^{-1}. The number of hydrogens in the molecular formula of the hydrocarbon is therefore
A. 8
B. 12
C. 16
D. 20
E. none of these
ANS: C

Section 2: Properties of Particles and Light

Consider the two slit interference on a screen experiment shown below for questions 12-15.



12. Which is true around point B 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/dark.
    E. None of these.
    ANS: A and C

13. Which is true around point A 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.
    ANS: B and D

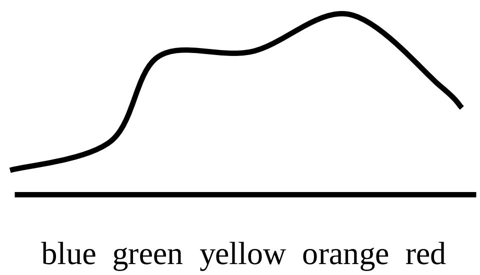
14. Which is true for a two slit experiment with baseballs (mark all that apply)?

    A. Constructive interference occurs.
    B. Destructive interference occurs.
    C. The probability of baseball impacts follows the light example.
    D. The probability of baseball impacts follows the electron example.
    E. None of these.
    ANS: E

15. Which is true for an experiment with light of a lower frequency (with the same intensity. Mark all that apply)?

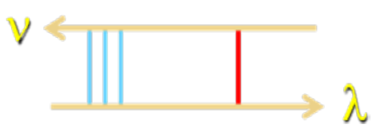
    A. Photon wavelengths increase.
    B. The distance between bright spots increases
    C. More photons strike the screen per second.
    D. The amplitude of the wave pattern decreases.
    E. None of these.
    ANS: A and B.

16. Which is the best description of the color of an object with the following absorption spectrum?



A. yellow
B. red
C. orange
D. white
E. blue
E

17. To which energy level scheme does the emission spectrum correspond?



ANS: B

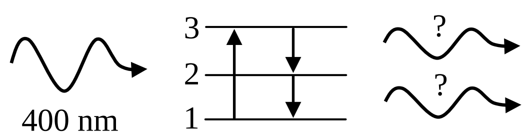
18. Red light has a __________ frequency and a __________ wavelength than blue light.
A. higher, longer
B. lower, longer
C. higher, shorter
D. lower, shorter
ANS: B

19. Light of wavelength 1000 nm is in the _________ region of the electromagnetic spectrum.
A. infrared

B. microwave
C. ultraviolet
D. x-ray
E. visible
ANS: A

20. Blue, red, yellow and green light eject electrons from the surface of potassium. In which case do the ejected electrons have the highest average kinetic energy?
A. blue
B. red
C. yellow
D. green
E. they all eject electrons of the same average kinetic energy
ANS: A

21. A photon of blue light (400 nm) is absorbed and 2 photons are emitted as illustrated in the energy diagram below. To which color light do the two equivalent emitted photons correspond?



A. IR
B. Yellow
C. Green
D. Blue
E. UV
ANS: A

22. Calculate the energy of a photon of light having a frequency of 8.927×10^{14} s^{-1}.
A. 7.423×10^{-49} J
B. 5.915×10^{-19} J
C. 5.915×10^{-12} J
D. 1.347×10^{14} J
E. none of these
ANS: B

23. How many photons are contained in a flash of green light (525 nm) that contains 189 kJ of energy?
A. 5.67×10^{23} photons
B. 2.01×10^{24} photons
C. 1.25×10^{31} photons
D. 4.99×10^{23} photons

E. 7.99×10^{30} photons
ANS: D

24. Determine the energy of 1 mol of photons for visible light of 500 nm.
A. 239 kJ
B. $3.98 * 10^{-19}$ J
C. $5.98 * 10^{-7}$ J
D. $6.02 * 10^{23}$
E. 300 J
ANS: A

SECTION 3: QUANTUM MECHANICS

25. What is the de Broglie wavelength of a 143 g baseball traveling at 95 mph (1 mile = 1.609 km).

A. $1.1 * 10^{-34}$ m
B. $5.5 * 10^{-33}$ m
C. $1.4 * 10^{-23}$ m
D. 2600 m
E. 39 m

ANS: A

26. Light of 450 nm wavelength will eject electrons from a metal sample. Which also must be true?

A. Light of 500 nm will also eject electrons.
B. Light of 400 nm will also eject electrons.
C. 450 nm light of greater intensity will eject electrons with greater kinetic energy.
D. 600 nm light will eject electrons provided the intensity is great enough.
E. None are true.

ANS: B

27. In the photoelectric effect, light directed onto the surface of metal in a vacuum causes electrons to be ejected. As the intensity of the light increases,

A. the kinetic energy of the ejected electrons increases.
B. the kinetic energy of the ejected electrons decreases.
C. the number of ejected electrons increases.
D. the number of ejected electrons decreases.
E. none of these, because the number and energy of the ejected electrons is independent of intensity.

ANS: C

28. Light of wavelength 400 nm strikes a clean surface of metallic Cs in vacuum and ejects an electron having kinetic energy 1.54×10^{-19} J. Calculate the de Broglie wavelength of this electron.

A. 1.25 nm
B. 400 nm
C. 579 nm
D. 1290 nm
E. 4.72×10^{15} nm

ANS: A

29. The de Broglie wavelength of an electron moving with velocity 1.00×10^{6} m s^{-1} is 7.27 Å. Therefore, to achieve a de Broglie wavelength of 5.00 Å, an electron must move with velocity

A. 4.73×10^{5} m s^{-1}
B. 6.88×10^{5} m s^{-1}
C. 1.45×10^{6} m s^{-1}
D. 2.11×10^{6} m s^{-1}
E. none of these

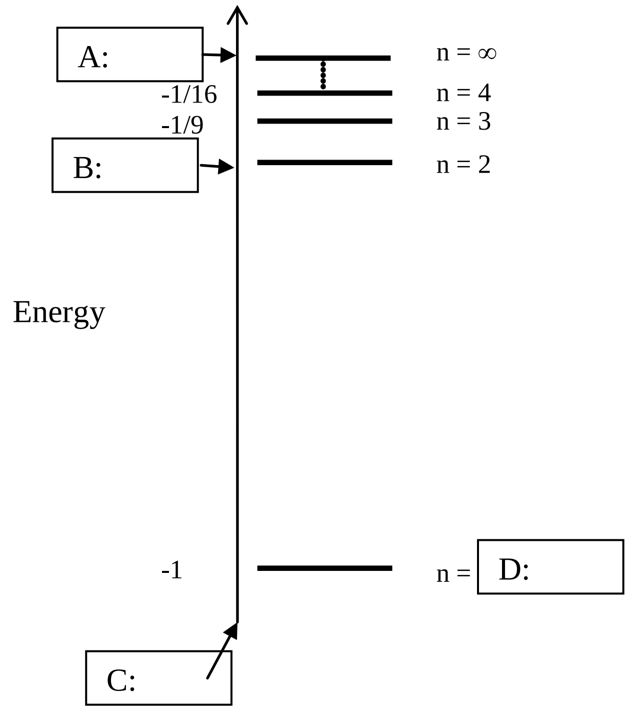
ANS: C

30. Calculate the wavelength of light emitted when the electron in a hydrogen atom undergoes a transition from $n = 4$ to $n = 3$.
A. 1.060×10^{-19} nm
B. 1.094×10^{-6} nm
C. 91.13 nm
D. 1094 nm
E. 1875 nm
ANS: E

31. When a gaseous magnesium ion gains an electron to become a gaseous magnesium atom, does it absorb or release energy?
A. absorb
B. release
ANS: B

32. It requires $2.08 * 10^{-18}$ J to eject an electron from one atom of Cl. If you shine light that has an energy of $5.20 * 10^{-18}$ J on one Cl atom, how much kinetic energy would you expect the electron to have?
A. $3.12 * 10^{-18}$ J
B. $7.28 * 10^{-18}$ J
C. 0 J
D. $- 3.12 * 10^{-18}$ J
E. $- 7.28 * 10^{-18}$ J
ANS: A

Consider the following diagram showing the energy levels of one Hydrogen atom for the following questions 33 - 37.



33. In what units is the energy expressed?

A. Joules
B. Kilojoules
C. Hertz (frequency)
D. Rydbergs
E. Kelvins

ANS: D

34. Which value belongs in box A?

A. -1
B. -1/4
C. 0
D. 1
E. none of these

ANS: C

35. Which value belongs in box B?

A. -1
B. -1/4
C. 0

D. 1
E. none of these

ANS: B

36. Which value belongs in box C?

A. -1
B. -1/4
C. 0
D. 1
E. none of these

ANS: E

37. Which value belongs in box D?

A. -1
B. -1/4
C. 0
D.1
E. none of these

ANS: D

38. Which set of quantum numbers is not possible (mark all that apply)?

A. $n = 1, \ell = 0, m_\ell = 1$

B. $n = 2, \ell = 0, m_\ell = 0$

C. $n = 3, \ell = 3, m_\ell = 1$

D. $n = 4, \ell = 0, m_\ell = 1$

E. $n = 5, \ell = 4, m_\ell = 4$

ANS: A, C, D

SECTION 4: LABORATORY

39. The requirements for the airbag that you developed in the first lab were that it could be deployed at a given time and that it inflates to the largest possible volume. The constraints on the airbag design were that it could not weigh more than 3.5 g and you could only use the materials available. The chemical reaction that you used to produce the gas (CO_2) was:

$$NaHCO_3(s) + CH_3COOH(aq) \rightarrow CO_2(g) + CH_3COONa(aq) + H_2O(l)$$

If you are given an apparatus design that weighs 1.95 g (without the addition of the reaction chemicals); what is the maximum amount of CO_2 that you can produce at 0^oC? You can assume that the concentration of CH_3COOH is 100%. The molar volume of CO_2 at this condition is 22.4 L.

A. 240 mL
B. 650 mL
C. 11 mL
D. 904 mL
E. 470 mL

ANS: A

40. When estimating the number of stearic acid molecules in the monolayer in the experiment "Determination of Avogadros number", which of the following is not needed for calculation?

A. the diameter of the watch glass

B. total volume of stearic acid solution in test tube before rinsing the dropper pipette

C. the number of drops of stearic acid required to form the monolayer

D. molecular geometry of stearic acid

ANS: B and C

EVERYONE was credited 3 points for this question regardless of the answer.
The question should have specified "Mark all that apply."

hydrogen 1 **H** 1.0079																		helium 2 **He** 4.0026
lithium 3 **Li** 6.941	beryllium 4 **Be** 9.0122												boron 5 **B** 10.811	carbon 6 **C** 12.011	nitrogen 7 **N** 14.007	oxygen 8 **O** 15.999	fluorine 9 **F** 18.998	neon 10 **Ne** 20.180
sodium 11 **Na** 22.990	magnesium 12 **Mg** 24.305												aluminium 13 **Al** 26.982	silicon 14 **Si** 28.086	phosphorus 15 **P** 30.974	sulfur 16 **S** 32.065	chlorine 17 **Cl** 35.453	argon 18 **Ar** 39.948
potassium 19 **K** 39.098	calcium 20 **Ca** 40.078		scandium 21 **Sc** 44.956	titanium 22 **Ti** 47.867	vanadium 23 **V** 50.942	chromium 24 **Cr** 51.996	manganese 25 **Mn** 54.938	iron 26 **Fe** 55.845	cobalt 27 **Co** 58.933	nickel 28 **Ni** 58.693	copper 29 **Cu** 63.546	zinc 30 **Zn** 65.39	gallium 31 **Ga** 69.723	germanium 32 **Ge** 72.61	arsenic 33 **As** 74.922	selenium 34 **Se** 78.96	bromine 35 **Br** 79.904	krypton 36 **Kr** 83.80
rubidium 37 **Rb** 85.468	strontium 38 **Sr** 87.62		yttrium 39 **Y** 88.906	zirconium 40 **Zr** 91.224	niobium 41 **Nb** 92.906	molybdenum 42 **Mo** 95.94	technetium 43 **Tc** [98]	ruthenium 44 **Ru** 101.07	rhodium 45 **Rh** 102.91	palladium 46 **Pd** 106.42	silver 47 **Ag** 107.87	cadmium 48 **Cd** 112.41	indium 49 **In** 114.82	tin 50 **Sn** 118.71	antimony 51 **Sb** 121.76	tellurium 52 **Te** 127.60	iodine 53 **I** 126.90	xenon 54 **Xe** 131.29
caesium 55 **Cs** 132.91	barium 56 **Ba** 137.33	57-70 *	lutetium 71 **Lu** 174.97	hafnium 72 **Hf** 178.49	tantalum 73 **Ta** 180.95	tungsten 74 **W** 183.84	rhenium 75 **Re** 186.21	osmium 76 **Os** 190.23	iridium 77 **Ir** 192.22	platinum 78 **Pt** 195.08	gold 79 **Au** 196.97	mercury 80 **Hg** 200.59	thallium 81 **Tl** 204.38	lead 82 **Pb** 207.2	bismuth 83 **Bi** 208.98	polonium 84 **Po** [209]	astatine 85 **At** [210]	radon 86 **Rn** [222]
francium 87 **Fr** [223]	radium 88 **Ra** [226]	89-102 **	lawrencium 103 **Lr** [262]	rutherfordium 104 **Rf** [261]	dubnium 105 **Db** [262]	seaborgium 106 **Sg** [266]	bohrium 107 **Bh** [264]	hassium 108 **Hs** [269]	meitnerium 109 **Mt** [268]	ununnilium 110 **Uun** [271]	unununium 111 **Uuu** [272]	ununbium 112 **Uub** [277]		ununquadium 114 **Uuq** [289]				

*Lanthanide series	lanthanum 57 **La** 138.91	cerium 58 **Ce** 140.12	praseodymium 59 **Pr** 140.91	neodymium 60 **Nd** 144.24	promethium 61 **Pm** [145]	samarium 62 **Sm** 150.36	europium 63 **Eu** 151.96	gadolinium 64 **Gd** 157.25	terbium 65 **Tb** 158.93	dysprosium 66 **Dy** 162.50	holmium 67 **Ho** 164.93	erbium 68 **Er** 167.26	thulium 69 **Tm** 168.93	ytterbium 70 **Yb** 173.04
**Actinide series	actinium 89 **Ac** [227]	thorium 90 **Th** 232.04	protactinium 91 **Pa** 231.04	uranium 92 **U** 238.03	neptunium 93 **Np** [237]	plutonium 94 **Pu** [244]	americium 95 **Am** [243]	curium 96 **Cm** [247]	berkelium 97 **Bk** [247]	californium 98 **Cf** [251]	einsteinium 99 **Es** [252]	fermium 100 **Fm** [257]	mendelevium 101 **Md** [258]	nobelium 102 **No** [259]