Name Jun

SECTION 1: STOICHIOMETRY

1.) What is the coefficient of oxygen in the balanced combustion reaction of one (1) mole of acetone (C_3H_6O)?

$$C_3H_6O + 4O_2 \rightarrow 3CO_2 + 3H_2O$$

A) 1 B) 2 C) 3 D) 4 E) 5

For the next four questions consider a gaseous hydrocarbon X which contains only carbon and hydrogen. It has a relative molar mass 2.25 times greater than molecular oxygen. The balanced combustion reaction of one mole of hydrocarbon X is:

$$1\,X + 8\,O_2 \rightarrow 5\,CO_2 + 6\,H_2O$$

5 mol C
12 mol H

C_5H_{12} → 72

2.) What is the molecular formula for hydrocarbon X?

A) CH_4 B) C_2H_6 C) C_3H_8 D) C_4H_{10} E) C_5H_{12}

3.) What is the minimum mass (grams) of hydrocarbon X required to completely react with 4.0 g oxygen as shown (this *can* be determined without the previous result)?

A) 0.24 B) 0.50 C) 1.1 D) 5.0 E) 8.6

$$4g\ O_2 \times \frac{1\ mol\ O_2}{32g\ O_2} \times \frac{1\ mol\ X}{8\ mol\ O_2} \times \frac{72g\ X}{1\ mol\ X}$$

1.1 g × 1 g O₂ / 2.75

32 g O₂

4.) Which is true when 2.0 moles of hydrocarbon X react with 14.0 moles of oxygen?

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

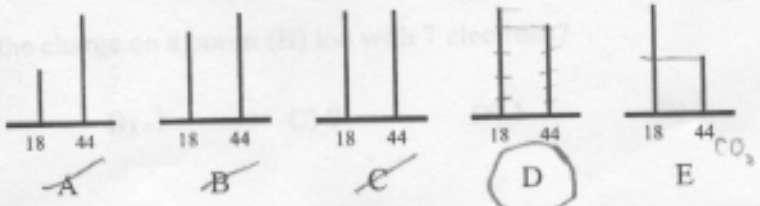
$$14\ mol\ O_2 \times \frac{1\ mol\ X}{8\ mol\ O_2} = 1.75\ mol\ X$$

LR

0.25 X left

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

more H_2O than CO_2



Continue with the next question:

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6.) What is the mass (in grams) of 4 L of gasoline if the density of gasoline is 0.79 g/ml?

A) 2.2e3 B) 3.2e3 C) 4.3e3 D) 5.4e3 E) 6.5e3

3.2e3

$D = \frac{M}{V}$

$M = VD$

$M = 4\,L \times \frac{0.79\,g}{mL} \times \frac{10^3\,mL}{1\,L}$

7.) A 54 g sample of aluminum reacts completely with 48.0 g of oxygen gas. Which is the formula of the oxide?

A) Al_2O_3 B) AlO C) AlO_2 D) Al_6O_5 E) Al_3O_5

$Al + O_2 \rightarrow Al_2O_3$

$54\,g\,Al \times \frac{1\,mol\,Al}{26.98\,g} = 2\,Al \times 2 = 4$

$48\,g\,O_2 \times \frac{1\,mol}{32\,g} = 1.5 \times 2 = 3$

Al_2O_3

SECTION 2: ATOMIC STRUCTURE

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

13 Al - 15

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

9.) How many protons are there in a gold (Au) nucleus?

196.97

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

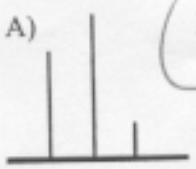
79

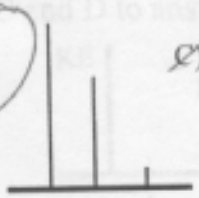
10.) What is the charge on a boron (B) ion with 7 electrons?

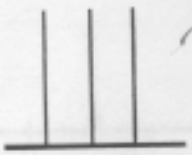
A) -2 B) -1 C) 0 D) 1 E) 2

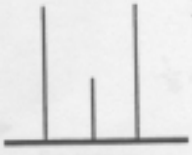
For the next three questions consider a 10 L sample of chlorine atoms in their natural relative abundances (3:1 ^{35}Cl : ^{37}Cl). The Cl atoms react to form Cl_2.

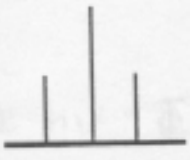
11.) Which is the most likely mass spectrum of the products?

A) 

B) 

C) 

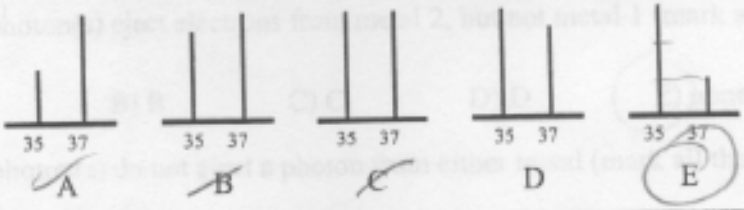
D) 

E) 

12.) What volume (in L) does the gas occupy after the reaction of the Cl atoms to form Cl_2?

A) 1 B) 5 C) 10 D) 15 E) 20

13.) Which is the mass spectrum if the Cl_2 is split back into atoms?

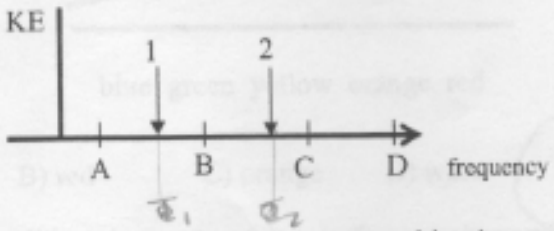


A B C D E

Continue with the next question:

SECTION 3: PROPERTIES OF LIGHT

Points 1 and 2 represent the work functions in frequency units of two different metals. The plot is of photo-electron kinetic energy vs. photon frequency for a photoelectric effect experiment. Use the photon frequencies labeled A, B, C and D to answer the following questions.



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

$E = h\nu - \Phi$

14.) Which photon ejects an electron with the greatest kinetic energy from metal 1?

A) A B) B C) C D) D E) none

15.) Which photon ejects an electron with the greatest kinetic energy from metal 2?

A) A B) B C) C D) D E) none

16.) Which photon(s) eject electrons from metal 1, but not metal 2 (mark all that apply)?

A) A B) B C) C D) D E) none

17.) Which photon(s) eject electrons from metal 2, but not metal 1 (mark all that apply)?

A) A B) B C) C D) D E) none

18.) Which photon(s) do not eject a photon from either metal (mark all that apply)?

A) A B) B C) C D) D E) none

19.) The frequency at point 'A' is 7.1×10^{14} Hz in the violet region of the visible spectrum. What is wavelength of a photon with this frequency (in nm)? (hint: no calculation necessary)

$c = \lambda\nu$

$\lambda = \frac{c}{\nu} = \frac{3\times10^8 m/s \times \frac{10^9}{1m}}{7.1\times10^{14}}$

A) 120 B) 150 C) 220 D) 330 E) 420

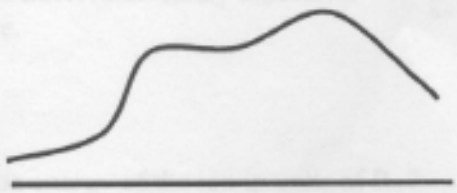
20.) The frequency at point 'A' is 7.1×10^{14} Hz in the violet region of the visible spectrum. What is energy of a photon with this frequency (in joules)?

$E = h\nu$

A) 5.2e23 B) 4.7e-19 C) 6.0e-34 D) 2.3e-18 E) 7.2e10

Continue with the next question:

21.) Which is the best desctiption of the color of an object with the following absoprtion spectrum?



blue green yellow orange red

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

22.) Under which conditions is constructive interference observed at a point on the target screen in a two slit experiment with waves?

A) When waves from each slit arrive in-phase.
B) When waves from each slit arrive 90° out of phase.
C) When waves from each slit do not arrive at the point.
D) When waves from each slit arrive at different times.
E) Constructive interference is never observed.

SECTION 4: QUANTUM MECHANICS

Consider the electronic energy levels of the Li^{2+} ion for the following five questions.

23.) What is the ground state energy in units of R_∞ (Rydbergs)?

A) -9 B) -2.25 C) 0 D) 5 E) 9

24.) What is the first excited state energy?

A) -9 B) -2.25 C) 0 D) 5 E) 9

25.) What wavelength photon is required to excite this ion from its ground state to first excited state (nm)?

A) 1.00 B) 3.14 C) 13.5 D) 18.8 E) 20.4

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26.) Relative to an electronic energy level, which condition represents zero energy?

A) The electron and nucleus infinitely separated.
B) The ground state.
C) The nucleus.
D) n=0.
E) None of these.

$E = \frac{-Z^2}{n^2}$, $n \to \infty$

27.) What is the ionization energy of the ion in units of R_∞?

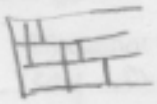
$-Z^2$

A) -9 B) -2.25 C) 0 D) 4 E) 9

Continue with the next question:

28.) How many unique spectral emission lines are observed from a system with four equally spaced energy levels?

A) 1 B) 2 C) 3 D) 4 E) 5



29.) Which excited state molecule or ion will have the smallest ionization energy?

A) $H(2p^1)$ $\frac{1}{4}$
B) $He(1s^13p^1)$ $\frac{1}{9}$
C) $Li(1s^24p^1)$ $\frac{1}{16}$
D) $Be(1s^22s^15p^1)$ $\frac{1}{25}$
E) $B(1s^22s^26p^1)$ $\frac{1}{36}$

$\frac{Z^2}{n^2}$ $\frac{1}{-}$

30.) Which is a possible electronic configuration for neutral silicon?

A) $[Ne]3s^23p^1$
B) $[Ne]3s^23p^2$
C) $[Ne]3s^23p^3$
D) $[Ne]3s^13p^6$
E) $[Ne]3s^23p^4$

14

For the next three questions, consider particles with the following masses (in kg) traveling at equal speeds:

A) 9.1e-31 B) 1.7e-27 C) 6.6e-28 D) 4.5e-19

31.) Which has the greatest momentum?

A) A B) B C) C D) D E) cannot be determined.

32.) Which has the greatest de Broglie wavelength? $\lambda = \frac{h}{mv}$

A) A B) B C) C D) D E) cannot be determined.

33.) A quantum particle never has zero energy when confined to a box (the lowest energy level is not zero). Normal (classical) particles can come to a rest and have zero energy. If confined in identical boxes, which would have the lowest ground state (of 'zero point') energy?

$E = \frac{hc}{\lambda}$ want biggest wavelength. OR $E = \frac{h^2}{8mL^2}$ biggest wavelength

$4.5e^{-4} > 9.1e^{-31}$

A) A B) B C) C D) D E) cannot be determined.

E very small for macroscopic systems

Continue with the next question:

34.) Which atomic orbital has the greatest number of radial nodes? total nodes = n − 1, angular nodes = ℓ

A) 1s (0 nodes) B) 2s (1 node) C) 2p (1 node) D) 3d (2 nodes) E) 4f (3 nodes)

0 1 2 3
s p d f

35.) Which wave form for a particle trapped in a 1-dimensional box has the highest energy?

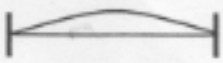
$E = h\nu$

$E = \frac{hc}{\lambda}$

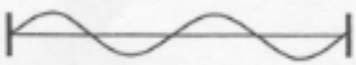
small wavelength

A)

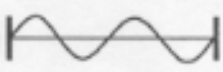
B)



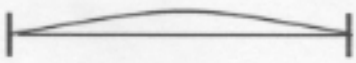
C)



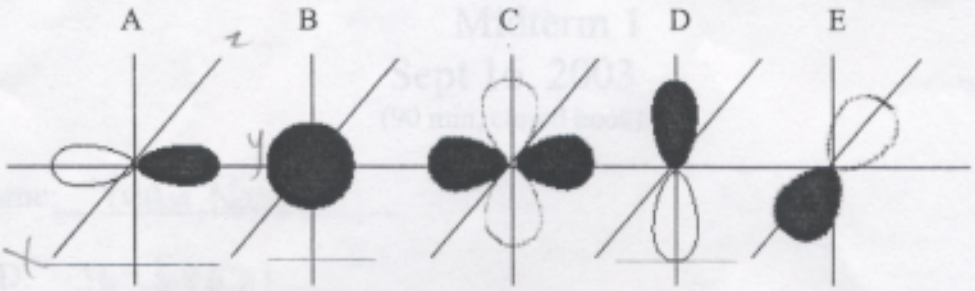
D)



E)



For the next three questions, consider the following set of five orbitals



36.) How many nodes are displayed in orbital 'D'?

A) 0 B) 1 C) 2 D) 3 E) 4

37.) What is the best label for orbital 'A'?

A) 1s B) 2s C) 2p D) 3s D) 3p

38.) Which orbital has the highest energy?

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