version: 292 Exam 2 - F22 - McCord - ch301

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1																	18
1 H 1.008	2											13	14	15	16	17	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3	4	5	6	7	8	9	10	11	12	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.64	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.20	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (267)	105 Db (268)	106 Sg (269)	107 Bh (270)	108 Hs (270)	109 Mt (278)	110 Ds (281)	111 Rg (282)	112 Cn (285)	113 Nh (286)	114 Fl (289)	115 Mc (290)	116 Lv (293)	117 Ts (294)	118 Og (294)

58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (266)

constants

$R = 0.08206$ L atm/mol K

$R = 8.314$ J/mol K

$N_A = 6.022 \times 10^{23}$ /mol

$h = 6.626 \times 10^{-34}$ J·s

$c = 3.00 \times 10^{8}$ m/s

$F = 96485$ C/mol e^-

$e = 1.602 \times 10^{-19}$ C

$m_e = 9.11 \times 10^{-31}$ kg

Rydberg Constants

$\mathcal{R} = 2.18 \times 10^{-18}$ J

$\mathcal{R} = 3.29 \times 10^{15}$ s^{-1}

$\mathcal{R} = 1.097 \times 10^{7}$ m^{-1}

conversions

1 atm = 760 torr

1 atm = 101325 Pa

1 atm = 1.01325 bar

1 atm = 14.7 psi

1 bar = 10^5 Pa

1 in = 2.54 cm

1 mi = 5280 ft

1 Å= 10^{-10} m

1 lb = 453.6 g

1 ton = 2000 lbs

1 tonne = 1000 kg

1 gal = 3.785 L

1 gal = 231 in^3

1 fl oz = 29.57 mL

conversions

1 cal = 4.184 J

1 eV = 1.602×10^{-19} J

1 kWh = 3600 J

water data

$C_{s,ice} = 2.09$ J/g °C

$C_{s,water} = 4.184$ J/g °C

$C_{s,steam} = 2.03$ J/g °C

$\rho_{water} = 1.00$ g/mL

$\rho_{ice} = 0.9167$ g/mL

$\rho_{seawater} = 1.024$ g/mL

$\Delta H_{fus} = 334$ J/g

$\Delta H_{vap} = 2260$ J/g

$K_w = 1.0 \times 10^{-14}$

This exam should have exactly 25 questions. Each question is equally weighted at 4 points each. You will enter your answer choices on the virtual bubblehseet after you have finished. Your score is based on what you submit on the virtual bubblesheet and not what is circled on the exam.

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1. How many joules of energy are in one photon that has a wavelength of 166 nm?

● a. 1.20×10^{-18} J

b. 1.01×10^{-40} J

c. 3.50×10^{-19} J

d. 1.75×10^{-18} J

e. 5.25×10^{-19} J

Explanation: $E = hc/\lambda$
$= 6.626 \times 10^{-34}(3 \times 10^{8})/166 \times 10^{-9} = 1.2 \times 10^{-18}$ J

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2. Which of these ionic compounds has the lowest theoretical lattice energy?

● a. KBr

b. CaO

c. $MgCl_2$

d. NaBr

e. $CaCl_2$

Explanation: The lowest lattice energy will involve the lowest chargest and the largest radius. First, you can identify that KBr and NaBr have the lowest charges (+1/-1). Then KBr has the larger radius, making it weaker.

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3. We conduct a photoelectric effect experiment using cesium and a light source of wavelength 540 nm. What is the velocity of the ejected electron from the surface of cesium? The work function (Φ) of cesium is 2.10 eV.

a. 6.96×10^{10} m/s

b. 1.06×10^{5} m/s

c. 1.33×10^{6} m/s

d. 3.11×10^{5} m/s

● e. 2.64×10^{5} m/s

Explanation:
work function in J $= 2.1(1.602 \times 10^{-19}) = 3.3642 \times 10^{-19}$
incoming photon E
$= 6.626 \times 10^{-34}(3 \times 10^{8})/540 \times 10^{-9} = 3.6811 \times 10^{-19}$
difference is $= 3.1691 \times 10^{-20}$ J
which is the kinetic energy of electron $= 1/2\ mv^2$
$v_{\text{electron}} = (2E_k/m)^{1/2}$
$\left(2(3.1691 \times 10^{-20})/9.11 \times 10^{-31}\right)^{1/2} = 2.638 \times 10^{5}$ m/s

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4. CCl_4 was historically used as a flame retardant chemical in fire extinguishers. Given the chemical formula, what is the name of CCl_4?

a. carbon chloride

● b. carbon tetrachloride

c. carbon tetrachlorine

d. carbon pentachloride

e. chlorine tetracarbide

Explanation: CCl_4 is a covalent compound. We start naming with carbon, as it is furthest left in the periodic table. Chlorine is next, but its suffix must be changed to -ide, it must also be given the correct prefix (tetra).

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5. Household bleach contains sodium hypochlorite, what is the corresponding chemical formula?

a. $NaClO_2$

b. Na_2ClO

● c. NaClO

d. $NaClO_3$

e. $Na(ClO)_2$

Explanation: Hypochlorite is the polyatomic ion ClO^-. To answer this question correctly, you also need to remember it has a -1 charge and that sodium always has a +1 charge as do all the alkali metals (group 1).

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6. What orbital property is the angular momentum quantum number (ℓ) associated with?

a. valence shell

● b. shape

c. electron spin

d. orientation in space

e. distance from nucleus

Explanation: ℓ respresents the shape of the orbital, as determined by the angular nodes. The other answer choices are all associated with specific quantum numbers.

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7. How many angular nodes would a theoretical 5g orbital have?

a. 1

● b. 4

c. 3

d. 2

e. 5

Explanation: A 5g orbital would have an angular momentum quantum number of $\ell = 4$, and thus would have 4 angular nodes.

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8. Which element/atom listed has the largest value for the effective nuclear charge (Z_{eff})?

a. Cs

b. Pb

c. Sn

d. In

● e. Te

Explanation: The effective nuclear charge increases as you go across a row (period) of the periodic table. The number of inner shell electrons that *shield* the full nuclear charge stay constant across the row, but the number of protons is increasings, thus increasing Z_{eff} and pulling the valence shell in tighter and smaller.

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9. Suppose X stands for a particular element on the periodic table. Select the atom or ion that will have the largest radius.

a. X

b. X^-

● c. X^{2-}

d. X^+

e. X^{2+}

Explanation: Anions becomes larger with the addition of each electron due to electron repulsions in the valence shell. The ion with the greatest negative charge will have the largest radius.

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10. What is the electron configuration of Bismuth (Bi)?

a. $[Rn]6p^3$

b. $[Xe]6s^26p^3$

c. $[Rn]7s^25f^{14}6d^{10}7p^3$

d. $[Xe]6s^25d^{10}6p^3$

e. $6s^24f^{14}5d^{10}6p^3$

● f. $[Xe]6s^24f^{14}5d^{10}6p^3$

Explanation: Electronic configurations can be abbreviated using the noble gases on the periodic table to respresent full valence shells. In the case of Bi, the closest previous noble gas is Xe. After the abbreviation, the electronic configuration is filled in by moving from left to right across the periodic table, taking care to not skip over the f-block elements.

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11. An electron in the hydrogen atom is excited and makes the energy jump from $n = 2$ to $n = 6$. What wavelength of light corresponds to this energy jump?

a. 434 nm

●b. 410 nm

c. 656 nm

d. 486 nm

e. 122 nm

Explanation: Use the Rydberg equation:
$E = \mathcal{R}\left(\frac{1}{n^2} - \frac{1}{n^2}\right)$
$= 2.18 \times 10^{-18}(1/4 - 1/36) = 4.844 \times 10^{-19}$ J
$\lambda = \frac{hc}{E} = 6.626 \times 10^{-34}(3 \times 10^8)/4.844 \times 10^{-19}$
$= 4.10 \times 10^{-7}$ m = 410 nm

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12. Which of the following choices correctly ranks the elements from the least electronegative to the most electronegative?

a. F < Ca < N < Sr < Cs

b. F < N < Cs < Sr < Ca

c. Sr < N < F < Cs < Ca

●d. Cs < Sr < Ca < N < F

e. F < N < Ca < Sr < Cs

Explanation: Electronegativity increases towards the top right corner of the periodic table, corresponding to the order: Cs < Sr < Ca < N < F.

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13. Which element has the largest atomic radius?

a. P

b. Br

c. Ar

d. S

●e. Sb

Explanation: Atomic radii increase moving down a group(column) on the periodic table and decrease moving to the right across a period(row) on the periodic table. Moving down a row results in a larger increase in atomic radius than moving over 1 element to the left because moving down represents gaining an additional shell of electrons. Moving to the left just eases the contraction that occurs by having an additional electron in the valence shell interacting with the nucleus.

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14. Which color of visible light corresponds to the highest frequency?

a. yellow

b. green

c. red

●d. blue

e. orange

Explanation: Blue light is the high energy end of the visible light spectrum. Since higher energy postively correlates with higher frequency, blue light is the high frequency end of the visible light spectrum as well.

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15. The following species are isoelectronic. Select the atom or ion that will have the largest radius.

a. Cl^-

b. K^+

●c. S^{2-}

d. Ar

e. Ca^{2+}

Explanation: Anions becomes larger with the addition of each electron due to electron repulsions in the valence shell. In this isoelectronic series, the sulfur ion has two extra electrons.

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16. Which orbital has the greatest number of radial nodes?

a. 4s

b. 5d

c. 4f

d. 6d

●e. 5s

f. 3s

Explanation: Radial nodes can be calculated using the equation: n-1-ℓ. A 5s orbital would have 4 radial nodes, this is the highest of any of the options listed.

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17. You meet Hank Hill, who sells propane and propane accessories. He asks if you, a chemistry student, can tell him the chemical formula of propane.

a. C_4H_8

●b. C_3H_8

c. C_4H_{10}

d. C_2H_6

e. C_3H_6

Explanation: This is a pure nomeclature problem. Propane is the third alkane, corresponding to 3 carbons. The generic formula for all alkanes is C_nH_{2n+2}.

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18. Which of the following wavelengths corresponds to an emission band in the Balmer series?

a. 9.53×10^{-1} m

●b. 4.86×10^{-7} m

c. 6.88×10^{-13} m

d. 1.72×10^{-4} m

e. 5.56×10^{-9} m

Explanation: 4.86×10^{-7} m is the same as 486 nm. This is the only option within the visible spectrum, all of the emissions in the Balmer series occur in the visible region of electromagnetic radiation.

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19. Below is a plot of sequential ionization energies. Which element is this?

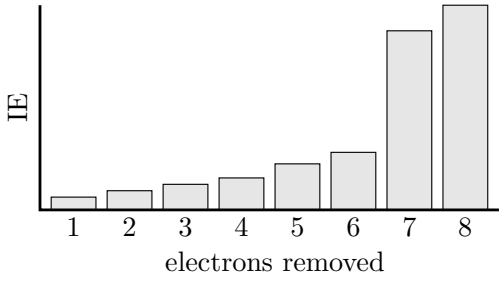
a. Cl

b. Mg

●c. S

d. P

e. Si



Explanation: It is clear that the first 6 electrons follow an increasing trend and then there is a big jump on the 7th. This will only match well with sulfur and it's 6 valence electrons ($3s^23p^4$). The 7th electron is a 2p electron and is much more difficult to remove to to its closer position to the nucleus.

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20. We are zapping various samples of metal with a laser ($\lambda = 525$ nm). As we increase the work function of the metal, the velocity of the emitted electron...

a. increases

b. it is impossible to know

c. electrons aren't emitted, protons are

d. stays the same

●e. decreases

Explanation: The same wavelength of light is used in every case, so the energy of the incoming photon is constant. As the workfunction increases in energy, the kinetic energy of the emitted photoelectron decreases, resulting in slower velocities.

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21. Which one of the atoms listed is paramagnetic?

a. xenon, Xe

b. mercury, Hg

c. cadmium, Cd

●d. titanium, Ti

e. magnesium, Mg

Explanation: Ti has $3d^2$ and those 2 electrons are not paired (Hund's Rule). This means that titanium is paramagnetic. The other choices all have matched (paired) sets of electrons completely filling a sublevel and making them all diamagnetic.

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22. Which quantum number set listed below could describe the highest energy valence electron of phosphorus?

●a. n=3, ℓ=1

b. n=3, ℓ=2

c. n=3, ℓ=0

d. n=4, ℓ=0

e. n=2, ℓ=1

Explanation: The outermost filled shell (valence) is 3s and 3p. The 3p set is higher in energy than the 3s orbital. The 4s is higher than all of them, except it is empty - so it can't be right.

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23. Television station KXAN in Austin is known as channel 36. That is in the UHF portion of communication frequencies. To be more specific, their video signal is on a carrier frequency of 603.25 MHz. Which of the following is the matching wavelength for this electromagnetic radiation?

a. 497 μm

b. 2.08 m

c. 4.97 m

● d. 49.7 cm

e. 20.8 cm

Explanation: $\lambda = c/\nu$
$= 3 \times 10^8 / 603.25 \times 10^6 = 0.497$ m $= 49.7$ cm

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24. What is the electron configuration for the bromide ion (Br^-)?

a. $[Ar]4s^2 3d^{10} 4p^4$

b. $[Ar]4s^2 4d^{10} 4p^6$

c. $[Kr]4s^2 4d^{10} 4p^4$

● d. $[Ar]4s^2 3d^{10} 4p^6$

e. $[Ar]4s^2 4p^4$

Explanation: Begin at [Ar] and include only the electrons that fill after. This will include the 3d electrons and the one extra electron for the negative charge: $[Ar]4s^2 3d^{10} 4p^6$

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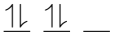
25. Which set of p orbitals below has been filled correctly? (they all have 4 electrons)

a.

● b. 

c. 

d. 

Explanation: According to Hund's Rule, you fill singly before pairing begins. Also you must match the spin state when you do fill singly. So the first 3 electrons go in separate orbitals and they all have up spin (+1/2). The fourth electron pairs with the first and has down spin (-1/2).

After you are finished and have all your answers circled, go to the front of the room and then use the QR code there to pull up the virtual answer page. Enter the appropriate info plus all your answers - click the SUBMIT button. Make sure you get the confirmation screen and show it to the TA or proctor. After that, turn in your exam and scratch paper. You're free to leave after that.

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