

Hour Exam #1

Not all pieces of information on this page are needed to complete this exam correctly

Physical constants and conversion Factors

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

$$1 \text{ eV} = 96.48 \text{ kJ/mol}$$

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

$$1 \text{ u} = 1.66 \times 10^{-24} \text{ g}$$

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

$$1 \text{ g/mol} = 9.000 \times 10^{10} \text{ kJ/mol}$$

$$1 \text{ u} = 1.661 \times 10^{-24} \text{ g}$$

$$h = 6.63 \times 10^{-34} \text{ J}\cdot\text{s}$$

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

Atomic Masses in atomic mass units (u)

$$\text{Proton mass} = 1.0072765$$

$$\text{Electron mass} = 0.0005486$$

$$\text{Neutron mass} = 1.0086650$$

$${}^1_1\text{H} = 1.0078250$$

$${}^{29}_{13}\text{Al} = 28.9804448$$

$${}^{31}_{14}\text{Si} = 30.9753633$$

$${}^{35}_{15}\text{P} = 34.9733142$$

$${}^{37}_{16}\text{S} = 36.9711257$$

Other useful information:

- 1) Periodic Chart attached
- 2) Nuclide symbols are written as ${}^A_Z\text{E}^{\pm n}$ where A=mass number, Z=atomic number, E=elemental symbol, and $\pm n$ is the charge

NOTE: SHOW ALL WORK FOR FULL CREDIT AND POSSIBLE PARTIAL CREDIT.

Problems/Questions (55 points - as noted)

- (1) Answer the following questions based on the Al-29 isotope, $^{29}_{13}\text{Al}$. (18 pts)
- How many protons, neutrons and electrons are in this atom?
 - On the periodic chart, which period and group houses this element
 - Is this nucleus stable or unstable and why?
 - If unstable, what kind of radioactive emission will occur and write its balanced nuclear decay reaction
 - Calculate the mass defect and binding energy per mole of nucleons.
 - How many electrons will this atom relatively easily lose before there is a large increase in its ionization energy?
- (2) For a H atom using Bohr's equations: (15 points)
- Calculate the energy, wavelength in nm, and frequency of a photon that causes an electron to move from the ground state to $n=6$.
 - Determine this energy in kJ for a mole of H atoms
 - Is this value consistent with the known ionization energy of the H-1 atom?
- (3) Using the quantum condition as imposed by both N. Bohr and L.V. deBroglie, calculate the velocity in m/s of an electron in the first principal level of the hydrogen atom. (Recall that $r = 52.9$ pm for an electron in $n=1$ of the Bohr atom.) (10 points)
- (4) Consider the 3s orbital. (12 points)
- Provide a set of quantum numbers that completely describe this orbital
 - Draw its radial probability distribution ($4\pi r^2 \psi^2$) and boundary surface diagrams.
 - How many planar and radial nodes does this orbital have? Identify them on the radial probability distribution diagram drawn in (b)
 - What is the first element on the periodic chart that has electrons in this orbital?

Multiple-Choice (circle the correct answer) (45 points – 3 each – Best 15 of 16 counted)

(1) A student isolates a pure substance A in the laboratory. She is able to separate A into simpler substances M and N, which she does not identify or characterize further. From this she correctly concludes:

- (a) A is a substance; M & N are elements
- (b) A is a compound; M & N are also compounds
- (c) A is a compound; M & N are elements
- (d) A is a compound; M & N may be elements or compounds

(2) Which statement is **false**?

- (a) Converting a compound into its elements is a chemical change
- (b) Separation of the components of a mixture is a physical change
- (c) The Law of Constant Composition refers to the constant number of protons in a given element
- (d) In mass spectroscopy the heavier ions bend the least under the influence of a magnetic field

(3) Which species has the same number of neutrons and electrons?

- (a) $^{40}_{18}\text{Ar}$
- (b) $^{39}_{17}\text{Cl}^{1-}$
- (c) $^{37}_{19}\text{K}^{1+}$
- (d) $^{46}_{21}\text{Sc}^{3+}$

(4) Which is not a mass?

- (a) atomic mass
- (b) atomic weight
- (c) mass number
- (d) mass defect

(5) Which radioactive atom might undergo predominantly positive beta (β^+) emission?

- (a) $^{30}_{16}\text{S}$
- (b) $^{260}_{98}\text{Cf}$
- (c) $^{20}_8\text{O}$
- (d) $^{62}_{29}\text{Cu}$

(6) A student wishes to find a source of negative beta particles, β^- . He also wants to have this source decay to gold (Au, Z=79) as it releases the negative beta particles. The best parent nuclide for him to use is:

- (a) $^{200}_{78}\text{Pt}$
- (b) $^{186}_{78}\text{Pt}$
- (c) $^{204}_{80}\text{Hg}$
- (d) $^{205}_{81}\text{Tl}$

(7) Which set of successive ionization energies (E_i) corresponds to an element in Group IVA (4A) of the periodic chart?

- (a) 0.8; 1.8; 19.6; 24.3; 28.7; 31.0
- (b) 0.6; 1.8; 3.2; 5.1; 24.6; 31.8
- (c) 1.2; 2.1; 3.1; 37.6; 42.0; 51.8
- (d) 1.7; 45.2; 63.8; 75.2; 86.7

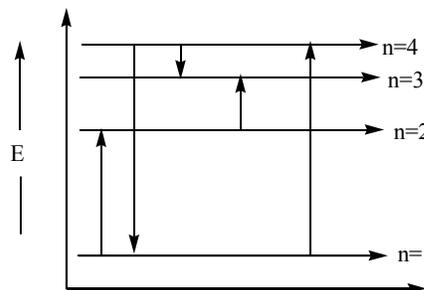
(8) Which change has $\Delta m > 0$?

- (a) $^{238}_{92}\text{U} + ^1_0\text{n} \rightarrow ^{134}_{54}\text{Xe} + ^{101}_{38}\text{Sr} + 3^1_0\text{n}$
- (b) $^2_1\text{H} + ^3_1\text{H} \rightarrow ^4_2\text{He} + ^1_0\text{n}$
- (c) $^{12}_6\text{C} + ^{42}_{18}\text{Ar} \rightarrow ^{54}_{24}\text{Cr}$
- (d) $^{60}_{26}\text{Fe} + ^{70}_{30}\text{Zn} \rightarrow ^{130}_{56}\text{Ba}$

(9) A photon of wavelength 1090 nm is ejected from a H atom when an electron falls from the sixth principal energy level. To which level does this electron fall?

- (a) 1 (b) 2 (c) 3 (d) 4

(10) Given the diagram to the right of some of the Bohr principal energy levels, circle the arrow that represents the absorption of a photon of longest wavelength?



(11) The idea that electrons, traditionally viewed as particles, could be treated as a wave phenomenon, is attributable to which scientist?

- (a) L. Victor deBroglie (b) Neils Bohr (c) Max Planck (d) Erwin Schrödinger

(12) Which set of three **quantum numbers** is not valid?

- (a) 3,2,-2 (b) 3,2,+1 (c) 3,1,-1 (d) 3,0,-1

(13) How many electrons may be described by the quantum numbers: $n = 2$, $l=1$

- (a) 1 (b) 2 (c) 3 (d) 6

(14) Which orbital has 2 nodes, neither of which is radial?

- (a) 2s (b) 2d (c) 3p (d) 3d

(15) Which does not belong?

- (a) orbital (b) (5,2) (c) volume element (d) wave function

(16) Which statement is true?

- (a) It is possible to simultaneously determine the precise location and velocity of an electron in an orbital
 (b) A set of quantum numbers that describes a 4s orbital is (4,1,0).
 (c) The Born Interpretation is that the wave function, Ψ , refers to the electron density at a distance, and not at a point
 (d) ΔE for an electronic transition in a H atom from $n=1$ to $n=\infty$ is 1312 kJ/mol.

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Other useful information:

- 1) Periodic Chart attached
- 2) Nuclide symbols are written as ${}^A_Z\text{E}^{\pm n}$ where A=mass number, Z=atomic number, E=elemental symbol, and $\pm n$ is the charge

NOTE: SHOW ALL WORK FOR FULL CREDIT AND POSSIBLE PARTIAL CREDIT.

Problems/Questions (55 points - as noted)

- (1) Answer the following questions based on the Si-31 isotope, $^{31}_{14}\text{Si}$. (18 pts)
- How many protons, neutrons and electrons are in this atom?
 - On the periodic chart, which period and group houses this element
 - Is this nucleus stable or unstable and why?
 - If unstable, what kind of radioactive emission will occur and write its balanced nuclear decay reaction
 - Calculate the mass defect and binding energy per mole of nucleons.
 - How many electrons will this atom relatively easily lose before there is a large increase in its ionization energy?
- (2) For a H atom using Bohr's equations: (15 points)
- Calculate the energy, wavelength in nm, and frequency of a photon that causes an electron to move from the ground state to $n=4$.
 - Determine this energy in kJ for a mole of H atoms
 - Is this value consistent with the known ionization energy of the H-1 atom?
- (3) Using the quantum condition as imposed by both N. Bohr and L.V. deBroglie, calculate the velocity in m/s of an electron in the second principal level of the hydrogen atom. (The radius $r = 75.4$ pm for an electron in $n=2$ of the Bohr atom.) (10 points)
- (4) Consider the 3p orbital. (12 points)
- Provide a set of quantum numbers that completely describe this orbital
 - Draw its radial probability distribution ($4\pi r^2 \psi^2$) and boundary surface diagrams.
 - How many planar and radial nodes does this orbital have? Identify them on the radial probability distribution diagram drawn in (b)
 - What is the first element on the periodic chart that has electrons in this orbital?

Multiple-Choice (circle the correct answer) (45 points (3 each) Best 15 of 16 counted)

(1) A student isolates a pure substance A in the laboratory. She is able to separate A into simpler substances M and N, which she does not identify or characterize further. From this she correctly concludes:

- (a) A is a substance; M & N are elements
- (b) A is a compound; M & N may be elements or compounds
- (c) A is a compound; M & N are also compounds
- (d) A is a compound; M & N are elements

(2) Which statement is **false**?

- (a) Converting a compound into its elements is a chemical change
- (b) Separation of the components of a mixture is a physical change
- (c) In mass spectroscopy the heavier ions bend the least under the influence of a magnetic field
- (d) The Law of Constant Composition refers to the constant number of protons in a given element

(3) Which species has the same number of neutrons and electrons?

- (a) $^{37}_{19}\text{K}^{1+}$
- (b) $^{39}_{17}\text{Cl}^{1-}$
- (c) $^{40}_{18}\text{Ar}$
- (d) $^{46}_{21}\text{Sc}^{3+}$

(4) Which is not a mass?

- (a) atomic mass
- (b) atomic weight
- (c) mass defect
- (d) mass number

(5) Which radioactive atom might undergo predominantly positive beta (β^+) emission?

- (a) $^{30}_{16}\text{S}$
- (b) $^{62}_{29}\text{Cu}$
- (c) $^{20}_{8}\text{O}$
- (d) $^{260}_{98}\text{Cf}$

(6) A student wishes to find a source of negative beta particles, β^- . He also wants to have this source decay to gold (Au, Z=79) as it releases the negative beta particles. The best parent nuclide for him to use is:

- (a) $^{186}_{78}\text{Pt}$
- (b) $^{200}_{78}\text{Pt}$
- (c) $^{204}_{80}\text{Hg}$
- (d) $^{205}_{81}\text{Tl}$

(7) Which set of successive ionization energies (E_i) corresponds to an element in Group IVA (4A) of the periodic chart?

- (a) 0.6; 1.8; 3.2; 5.1; 24.6; 31.8
- (b) 0.8; 1.8; 19.6; 24.3; 28.7; 31.0
- (c) 1.2; 2.1; 3.1; 37.6; 42.0; 51.8
- (d) 1.7; 45.2; 63.8; 75.2; 86.7

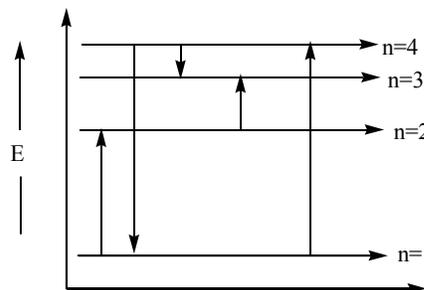
(8) Which change has $\Delta m > 0$?

- (a) $^{238}_{92}\text{U} + {}^1_0\text{n} \rightarrow {}^{134}_{54}\text{Xe} + {}^{101}_{38}\text{Sr} + 3{}^1_0\text{n}$
- (b) $^{60}_{26}\text{Fe} + {}^{70}_{30}\text{Zn} \rightarrow {}^{130}_{56}\text{Ba}$
- (c) ${}^2_1\text{H} + {}^3_1\text{H} \rightarrow {}^4_2\text{He} + {}^1_0\text{n}$
- (d) $^{12}_6\text{C} + {}^{42}_{18}\text{Ar} \rightarrow {}^{54}_{24}\text{Cr}$

(9) A photon of wavelength 1090 nm is ejected from a H atom when an electron falls from the sixth principal energy level. To which level does this electron fall?

- (a) 4 (b) 3 (c) 2 (d) 1

(10) Given the diagram to the right of some of the Bohr principal energy levels, circle the arrow that represents the emission of a photon of longest wavelength?



(11) The idea that electrons, traditionally viewed as particles, could be treated as a wave phenomenon, is attributable to which scientist?

- (a) Max Planck (b) Neils Bohr (c) L. Victor deBroglie (d) Erwin Schrödinger

(12) Which set of three **quantum numbers** is not valid?

- (a) 3,2,-2 (b) 3,2,-3 (c) 3,1,+1 (d) 3,0,0

(13) How many electrons may be described by the quantum number $n = 2$

- (a) 2 (b) 6 (c) 8 (d) 10

(14) Which orbital has 2 nodes, neither of which is radial?

- (a) 2s (b) 3d (c) 3p (d) 2d

(15) Which does not belong?

- (a) (5,2) (b) orbital (c) volume element (d) wave function

(16) Which statement is true?

- (a) It is possible to simultaneously determine the precise location and velocity of an electron in an orbital
 (b) A set of quantum numbers that describes a 4s orbital is (4,1,0).
 (c) The Born Interpretation is that the square of the wave function, Ψ^2 , refers to the electron density at a point
 (d) ΔE for an electronic transition in a H atom from $n=1$ to $n=\infty$ is 686 kJ/mol.

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Problems/Questions (55 points - as noted)

- (1) Answer the following questions based on the P-35 isotope, $^{35}_{15}\text{P}$. (18 pts)
- How many protons, neutrons and electrons are in this atom?
 - On the periodic chart, which period and group houses this element
 - Is this nucleus stable or unstable and why?
 - If unstable, write its balanced nuclear decay reaction (only one possibility and/or daughter needed)
 - Calculate the mass defect and binding energy per mole of nucleons.
 - How many electrons will this atom relatively easily lose before there is a large increase in its ionization energy?
- (2) For a H atom using Bohr's equations: (15 points)
- Calculate the energy, wavelength, and frequency of a photon that causes an electron to move from the ground state to $n=7$.
 - Determine this energy for a mole of H atoms
 - Is this value consistent with the known ionization energy of the H-1 atom?
- (3) Using the quantum condition as imposed by both N. Bohr and L.V. deBroglie, calculate the radius in nm of an electron in the third principal level of the hydrogen atom, assuming that the velocity of the electron in $n=3$ is 2280 m/s. (10 points)
- (4) Consider the 2s orbital. (12 points)
- Provide a set of quantum numbers that completely describe this orbital
 - Draw its radial probability distribution ($4\pi r^2 \psi^2$) and boundary surface diagrams.
 - How many planar and radial nodes does this orbital have? Identify them on the radial probability distribution diagram drawn in (b)
 - What is the first element on the periodic chart that has electrons in this orbital?

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- (c) $^{20}_8\text{O}$
- (d) $^{260}_{98}\text{Cf}$

(6) A student wishes to find a source of negative beta particles, β^- . He also wants to have this source decay to gold (Au, $Z=79$) as it releases the negative beta particles. The best parent nuclide for him to use is:

- (a) $^{205}_{81}\text{Tl}$
- (b) $^{186}_{78}\text{Pt}$
- (c) $^{204}_{80}\text{Hg}$
- (d) $^{200}_{78}\text{Pt}$

(7) Which set of successive ionization energies (E_i) corresponds to an element in Group IIIA (3A) of the periodic chart?

- (a) 0.8; 1.8; 19.6; 24.3; 28.7; 31.0
- (b) 0.6; 1.8; 3.2; 5.1; 24.6; 31.8
- (c) 1.2; 2.1; 3.1; 37.6; 42.0; 51.8
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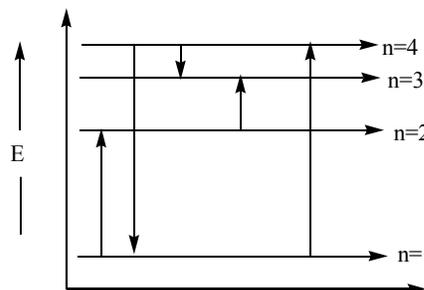
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- (b) $^{238}_{92}\text{U} + ^1_0\text{n} \rightarrow ^{134}_{54}\text{Xe} + ^{101}_{38}\text{Sr} + 3^1_0\text{n}$
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(9) A photon of wavelength 1090 nm is ejected from a H atom when an electron falls from the sixth principal energy level. To which level does this electron fall?

- (a) 1 (b) 4 (c) 2 (d) 3

(10) Given the diagram to the right of some of the Bohr principal energy levels, circle the arrow that represents the absorption of a photon of shortest wavelength?



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(12) Which set of three **quantum numbers** is not valid?

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(13) How many electrons may be described by the quantum numbers: $n = 2$, $l=1$, $m_l=0$

- (a) 1 (b) 2 (c) 3 (d) 6

(14) Which orbital has 2 nodes, neither of which is radial?

- (a) 3d (b) 2d (c) 2d (d) 3d

(15) Which does not belong?

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