

Physics 221

Quiz 9, Form: A

Name: _____

Date: _____

1. If you model a diatomic molecule, like O_2 , as two atoms connected by a spring, what are the three types of energies it can have? List and describe each one, and remember that Dr. Titus likes pictures!

2. If white light (containing photons of all energies in the visible region of the spectrum, from 1.8 eV to 3.1 eV) is incident on a gas of atomic hydrogen, only certain photons will be absorbed. One such absorbed photon has an energy of 1.89 eV. The hydrogen atom that absorbed such a photon increases in energy from
 - (a) $N=1$ to $N=2$.
 - (b) $N=1$ to $N=3$.
 - (c) $N=1$ to $N=4$.
 - (d) $N=2$ to $N=3$.
 - (e) $N=3$ to $N=4$.

3. Laser light containing photons of energy 1.96 eV (red) is incident on a low-temperature gas of atomic hydrogen. Because of its low temperature, nearly all of the atoms have energies equal to the ground state energy. The photons will
 - (a) be absorbed by hydrogen atoms in the gas.
 - (b) will be partially absorbed by the gas, meaning that some photons will be absorbed but not all of them.
 - (c) will pass through the gas without losing any energy or being absorbed.
 - (d) will pass through the gas, but will lose kinetic energy as a result of colliding with electrons in the hydrogen atoms.

4. A quantum oscillator loses vibrational energy as it makes a transition from $N=3$ to $N=1$. For this particular oscillator, the energy difference between successive levels is 0.012 eV. The emitted photon will have an energy of
 - (a) 0.012 eV
 - (b) 0.024 eV
 - (c) 0.036 eV
 - (d) 0.048 eV
 - (e) none of the above because photons cannot be emitted by quantum oscillators

5. A energy of the photon emitted by the oscillator in the previous question is in what region of the spectrum? This is typical for photons emitted as a result of transitions in vibrational energy for a diatomic molecule like Cl_2 .
- (a) infrared
 - (b) visible
 - (c) ultraviolet
 - (d) x-rays
 - (e) none of the above
6. A hypothetical atom, bowmanium, has allowed energies $E_3 = -10$ eV (the ground state), $E_2 = -11.9$ eV, $E_1 = -12.5$ eV, and $E_0 = -13$ eV. Suppose that the temperature is high enough so that for a gas of these atoms, there are atoms at any instant with energies in each one of these states. What are all of the possible energies of photons emitted from the gas?
7. Sketch a diagram for the previous question showing the energy levels and the various possible transitions. Use an arrow to represent an atom losing energy from some initial state (level) to some final state (level).

Answer Key for Exam A

1. electronic energy (energy associated with the configuration of the electron cloud; this is analogous to the electronic energy levels in atomic hydrogen) vibrational energy (potential and kinetic energy associated with the vibration of the molecule, like a harmonic oscillator) rotational energy (energy associated with the rotation of the molecule)

2. (d) 4. (b)
3. (c) 5. (a)

6. $E_3 - E_2$ $E_3 - E_1$ $E_3 - E_0$ $E_2 - E_1$ $E_2 - E_0$ $E_1 - E_0$

7. diagram should show unevenly spaced levels with 6 arrows, one arrow corresponding to each of the allowed transitions; the arrows must be pointed downward since the atom is losing energy in each case.