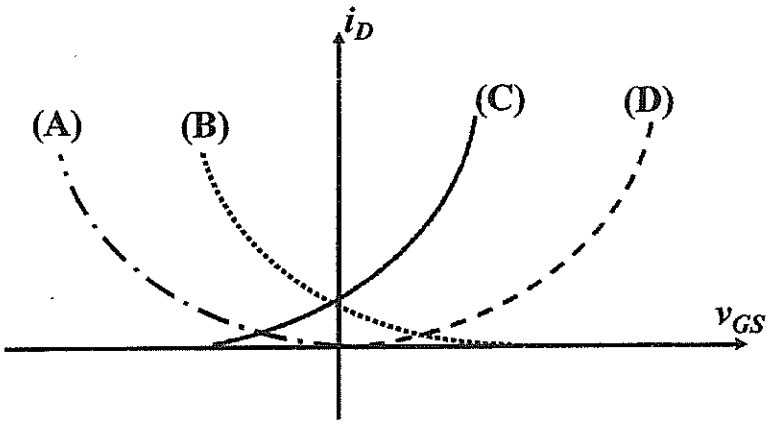
1. Solar energy reaches the Venus at the rate of about 3.2 kW/m^2 of surface perpendicular to the direction of the sun. By how much does the mass of the sun decrease per second owing to this energy loss? The mean radius of the Venus orbit is 1 x 10^{11} m. (9 %)

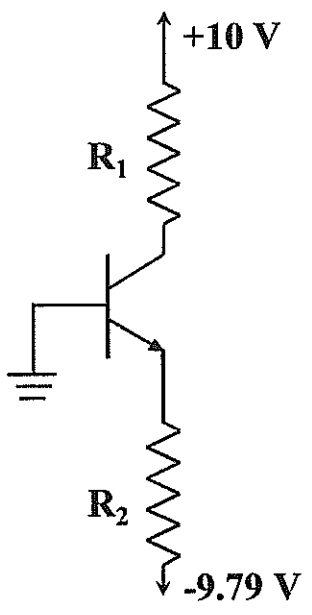
2. X-rays of wavelength 20 pm are scattered from a target electron. (a) Find the wavelength of the x-rays scattered through 60°. (b) Find the maximum wavelength presence in the scattered x-rays. (8 %) (Compton wavelength of the electron is ~2.5 pm.)

3. A hydrogen atom is ~5x10^{-11} m in radius. Use the uncertainty principle to estimate the minimum energy an electron can have in this atom. (electron mass= 9.1 x 10^{-31} kg, Planck constant = 6.626 x 10^{-34} J*s) (8 %)

4. Below is the sketch of the i_D-v_{GS} characteristics of MOSFETs operating in saturation mode. Identify p-channel enhancement-type, p-channel depletion-type, n-channel enhancement-type, and n-channel depletion-type MOSFET. (4 %) Also, depict simplified symbols for these four types of MOSFETS. Identify drain, source, and gate. DO NOT include body. (8 %)



5. The transistor in the circuit has β= 100 and exhibits v_{BE} of 0.7 V at i_C = 1 mA. Find R_1 and R_2, and i_E so that a current of 1 mA flows through the collector and a voltage of 5 V appears at the collector. (10 %) Find the value of i_E. (3 %)



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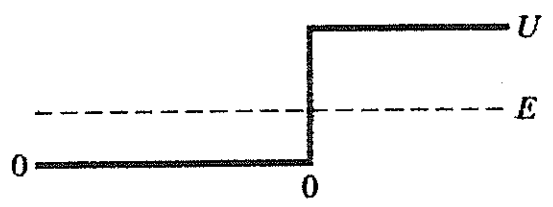
6. The electronic transitions that end in the state of quantum number n=2 is called the Balmer series in the hydrogen atom.
   (a) What is the longest wavelength of photons emitted? What is its energy? (5 %)
   (b) What is the shortest wavelength of photons emitted in the series? (5 %)

7. An excited atom can radiate a photon at any time, but the average time is called the lifetime, τ, of a particular excited state.
   (a) If τ=10 ns, please estimate the line width Δf of the photon emitted by the decay of this excited state. (5%)
   (b) If the wavelength of the spectral line in this process is 500 nm, what is the fractional broadening $\Delta f/f$? (5%)

8. Below shows a square potential barrier step where barrier width L is infinite. Briefly discuss the reflection, tunneling, and transmission situation of particles incident from the left on a potential step? Assume the step height U exceeds the total particle energy E. (10%)



9. Consider the number of electrons in the conduction bands of a bulk silicon (bandgap energy of 1.12 eV) and germanium (bandgap energy of 0.66 eV). Please estimate the "ratio" of the electron number between these two materials at temperature of 450 K. Assume the Fermi energy is at the center of the gap. (10 %)

10. Draw an I-V curve of a Si tunnel junction under forward bias. Use band diagrams to explain the phenomenon of "negative differential resistance." (10 %)

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