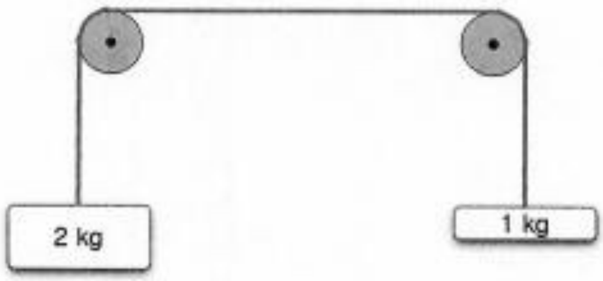
Quiz	DL Sec	Grading:	
Last 6 digits of student ID:		Name:	First three letters of your family name

1. Two masses are connected by a rope, which is pulled over two pulleys as shown below. The masses are placed as in the diagram below, but start to move when both masses are "released" (i.e. the person holding the masses in place lets go of both masses). The rope does not stretch as the masses move, and we may neglect any change of energy of the pulleys.



(a) Indicate if the 1 kg mass goes up or down once released. [1%]

(b) Indicate if the 2 kg mass goes up or down once released. [1%]

(c) When the 1 kg mass is released and has moved 10 cm, how far has the 2 kg mass travelled? We will refer to this state the *final state* in subsequent problems. [2%]

(d) What is the speed of the 1 kg mass moving in the final state? [10%]

(e) What is the speed of the 2 kg mass moving in the final state? [4%]

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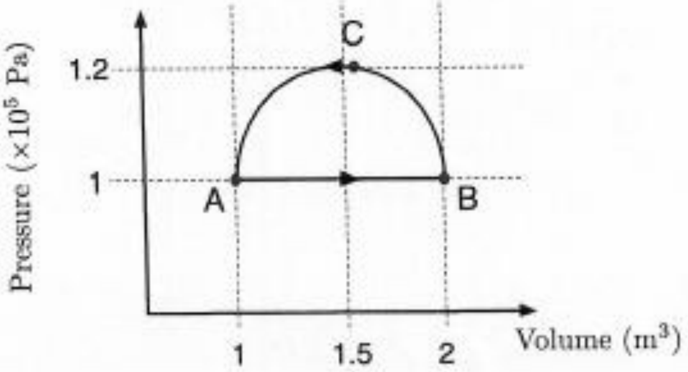
2. One mole of a diatomic (ideal) gas undergoes a cyclic process $A \to B \to C \to A$, where A, B and C are the points shown in the PV diagram.



(a) Does the internal energy increase, decrease or stay the same over one cycle? (i.e. pick one) [2%]

(b) Does heat flow into or out of the gas going from A to B? Pick one! [5%]

(c) Over an entire cycle, does more work enter the gas or leave it? (i.e. pick one!) [4%]

(d) Over an entire cycle, does more heat enter the gas or leave it? (i.e. pick one!) [4%]

(e) Is ΔS_{gas} positive, negative or zero for one cycle? (i.e. pick one!) Is this in conflict with the second law of thermodynamics? Explain why or why not. [5%]

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3. Two measurements of molar specific heat of the same substance are made in the temperature range 300–400 K. One is at constant pressure (c_p), the other is at constant volume (c_v). One experiment found a heat capacity of 20.8 J/ (mol K) and the other experiment measured 29.1 J/(mol K). Useful information:

$$R = 8.31\ \text{J/(mol K)}, \qquad k_B = 1.38 \times 10^{-23}\ \text{J/K}, \qquad N_A = 6.023 \times 10^{23}\ \text{atoms/mol}$$

(a) Which value is the molar specific heat at constant pressure? How can you tell? [5%]

(b) How many modes are activated at these temperatures (i.e. 300-400 K range)? [5%]

(c) Based on the number of modes, is this substance a solid, liquid or gas? If it is a gas specify if it is monatomic, diatomic, or "other". [5%]

(d) If we measured the molar specific heat at constant pressure at 2200 K, would you expect the value to be higher, lower or the same as the c_p at 300 K? (i.e. pick one). Explain. [5%]

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4. We start with a 2 gram ice-cube at $-50°$ C, and place it in an insulated cup. The inside of the insulated cup starts at +1° C and has a *very large heat capacity*. (In practical terms, this means you may neglect the change in temperature of the cup). You may assume that heat is only transferred between the cup and the H_2O inside. The following values may be useful to you:

c_{ice}	2.05 kJ/(kg K)
$\Delta H_{H_2O,s\to\ell}$	333.5 kJ/kg
c_{water}	4.18 kJ/(kg K)
0° C	273.15 K
Melting point of H_2O is 0° C	

(a) How much heat is exchanged from the cup to the H_2O?[5%]

(b) What is ΔS_{H2O} in going from the initial state to the equilibrium state?[5%]

(c) What is ΔS_{cup} in going from the the initial state to the equilibrium state?[4%]

(d) What is the *total* change in entropy of the universe for this process? Does this process violate the second law of thermodynamics?[2%]

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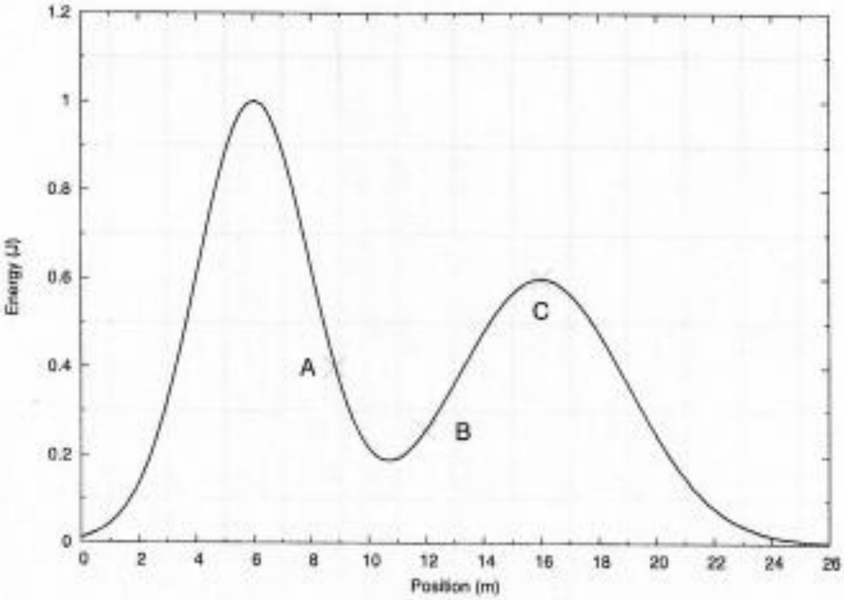
5. A ball rolls along a (frictionless) hill. The potential energy of the ball versus the horizontal location of the ball x is plotted below. Three points A, B and C are labelled and referenced in the problems below. You may neglect the kinetic energy due to rotation of the ball, but do *not* neglect the translational kinetic energy of the ball. Also assume that the potential energy approaches zero for $x < 0$ and $x > 26$ m (i.e. there are no "hills" hiding just off the graph).



(a) For each labelled point A, B and C indicate if the force on the particle points to the left, right or if it vanishes altogether. Note: we are not interested in the *vertical direction* of the force, only the horizontal direction. [4%]

(b) Rank the magnitude of the forces at each of A, B and C. [2%]

(c) If the ball starts at point B travelling *left*, is it possible for the ball to reach $x = 24$? If it is possible, what do we know about E_{tot} of the ball? Note: do **not** assume the ball starts at rest. [5%]

(d) If the ball starts at point B travelling *right*, is it possible for the ball to reach $x = 0$? If it is possible, what do we know about E_{tot} of the ball? Note: do **not** assume the ball starts at rest. [5%]

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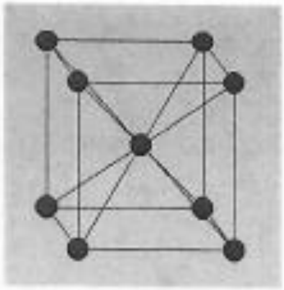

6. Every atom inside (i.e. not on the surface) of a solid block of sodium can be thought of the central atom in the diagram to the right. The nearest neighbours are 3.72Å apart. Recall 1Å$= 10^{-10}$ m.

(a) How many nearest neighbours does a sodium atom have? [1%]

(b) Using your answer above, and the fact that $\Delta H_{Na,\ell\to g} = 96.960$ kJ/mol, estimate the well-depth for the Lennard-Jones interaction between two sodium atoms. [8%]

(c) Use the equilibrium distance between nearest neighbours to estimate the diameter (i.e. "size") of a sodium atom. **Note:** The size of the atoms are *not* to scale with the bond lengths in the picture above. [1%]