**Assignment 5 - Thermodynamics Name: ………………….…………………..**

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| $$pV=nRT$$ | $$N\_{A}=6.02×10^{23}$$ |
| $$ΔU = ΔQ + ΔW$$ | $$R=8.31 J/K$$ |
| $$1 m^{3}=1000 litres$$ | $$P\_{0}=1.01×10^{5}Pa = 1 atm$$ |
| $$k\_{B}=1.38×10^{-23} J/K$$ |  |

1. Calculate the change in internal energy of a gas when 10 J of work are done on the gas and 8 J of heat are supplied to the gas. (1)
2. Calculate the change in internal energy of a gas when 13 J of work are done by the gas and 7 J of heat are supplied to the gas. (1)
3. Calculate the heat supplied to a gas when the internal energy increases by 13 J and 21 J of work are done by the gas. (1)
4. Calculate the work done to a system of gas when the internal energy increases by 5 J and 34 J of heat are transferred from the system. (1)
5. Sketch a PV diagram and find the work done on the gas during the following stages:
6. A gas is expanded from a volume of 1.0 x 10-2 m3 to 3.0 x 10-2 m3 at a constant pressure of 3.0 x 105 Pa. *Hint: be sure to label the axes.* (2)
7. The gas is then cooled at constant volume until the pressure falls to 2.0 x 105 Pa. *Hint: add this process on the diagram above and label it (b)* (2)
8. The gas is then compressed at a constant pressure of 2.0 x 105 Pa from a volume of 3.0 x 10-2 m3 to 1.0 x 10-2 m3. *Hint: as above!* (2)
9. The gas is heated until its pressure increases from 2.0 x 105 Pa to 3.0 x 105 Pa at a constant volume. (2)

(e) Find the net work done during the cycle. (2)

1. Calculate the efficiency of a heat engine that is supplied with 100 J of heat and completes 30 J of work. (2)
2. Calculate the efficiency of a heat engine that converts a quantity of heat into 500 J of work whilst transferring 300 J of heat to the surroundings. (2)
3. Calculate the efficiency of a heat engine that is supplied with 3.4 J of energy and which then, after converting some to work, transfers 1.2 J of this energy to a cold reservoir. (2)
4. One of the most efficient engines ever built is a coal-fired steam turbine engine in the Ohio River, driving an electric generator as it operates between 1870 °C and 430 °C.
5. What is the maximum theoretical efficiency? (1)

(b) Its actual efficiency is 42.0 %. How much mechanical power does the engine deliver if it absorbs 1.40 × 105 J of energy each second from the hot reservoir? (2)



1. A locomotive runs on a steam engine with a power output of 4.5 x 106 W and an efficiency of 12%.
2. Calculate the rate at which heat is being delivered to the steam engine. (2)
3. Calculate the magnitude of the resistive forces acting against the locomotive when it is moving at a constant speed of 7.0 m/s.

Suppose the gas in another heat engine follows the simplified path ABCDA in the PV diagram below at a rate of 4 cycles per second.



1. What does the area bounded by path ABCDA represent? (1)
2. Calculate the power output of the engine. (2)
3. Indicate below where heat is being added to the gas in the heat engine – justify your answer. (2)

………….. AB …………. BC ………….. CD …………. DA