Name: ______________________________ Date: ______________________________

Problem Set
THERMAL PHYSICS

Choose 3 and solve. Scan your solution and upload as a PDF file.

WARNING: If it's not a PDF file, it will not be given a feedback.

11 **a** Calculate the volume of 1 mol of helium gas (molar mass 4 g mol−1) at temperature 273 K and pressure 1.0 × 105 Pa. **[2]**

b **i** Find out how much volume corresponds to each molecule of helium. **[2]**

ii The diameter of an atom of helium is about 31 pm. Discuss whether or not the ideal gas is a good approximation to the helium gas in **a**. **[2]**

c Consider now 1 mol of lead (molar mass $207\,\mathrm{g\,mol^{-1}}$, density $11.3 \times 10^3\,\mathrm{kg\,m^{-3}}$). How much volume corresponds to each atom of lead? **[3]**

d Find the ratio of these volumes (helium to lead) and hence determine the order of magnitude of the ratio: separation of helium atoms to separation of lead atoms. **[2]**

12 a Define what is meant by **specific heat capacity** of a substance. **[1]**

b Consider two metals that have different specific heat capacities. The energies required to increase the temperature of 1 mol of aluminium and 1 mol of copper by the same amount are about the same. Yet the specific heat capacities of the two metals are very different. Suggest a reason for this. **[2]**

A hair dryer consists of a coil that warms air and a fan that blows the warm air out. The coil generates thermal energy at a rate of 600 W. Take the density of air to be $1.25\,\mathrm{kg\,m^{-3}}$ and its specific heat capacity to be $990\,\mathrm{J\,kg^{-1}\,K^{-1}}$. The dryer takes air from a room at 20 °C and delivers it at a temperature of 40 °C.

c What mass of air flows through the dryer per second? **[2]**

d What volume of air flows per second? **[1]**

e The warm air makes water in the hair evaporate. If the mass of water in the air is 180 g, calculate how long it will take to dry the hair. (The heat required to evaporate 1 g of water at 40 °C is 2200 J.) **[2]**

14 A piece of tungsten of mass 50 g is placed over a flame for some time. The metal is then quickly transferred to a well-insulated aluminium calorimeter of mass 120 g containing 300 g of water at 22 °C. After some time the temperature of the water reaches a maximum value of 31 °C.

a State what is meant by the internal energy of a piece of tungsten. **[1]**

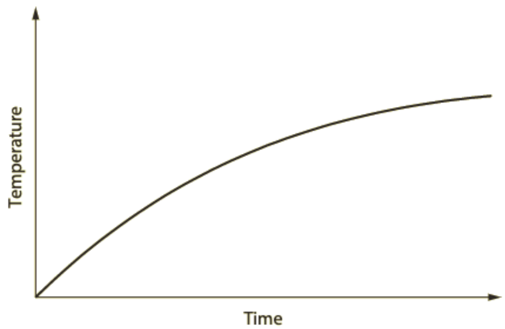
b Calculate the temperature of the flame. You may use these specific heat capacities: water $4.2 \times 10^3\,\mathrm{J\,kg^{-1}\,K^{-1}}$, tungsten $1.3 \times 10^2\,\mathrm{J\,kg^{-1}\,K^{-1}}$ and aluminum $9.0 \times 10^2\,\mathrm{J\,kg^{-1}\,K^{-1}}$. **[3]**

c State and explain whether the actual flame temperature is higher or lower than your answer to **b**. **[2]**

15 a Describe what is meant by the internal energy of a substance. **[1]**

b A student claims that the kelvin temperature of a body is a measure of its internal energy. Explain why this statement is not correct by reference to a solid melting. **[2]**

c In an experiment, a heater of power 35 W is used to warm 0.240 kg of a liquid in an uninsulated container. The graph shows the variation with time of the temperature of the liquid.



The liquid never reaches its boiling point.

Suggest why the temperature of the liquid approaches a constant value. **[2]**

d After the liquid reaches a constant temperature the heater is switched off. The temperature of the liquid decreases at a rate of 3.1 K min^{-1}.

Use this information to estimate the specific heat capacity of the liquid. **[3]**

16 The volume of air in a car tyre is about $1.50 \times 10^{-2}\,m^3$ at a temperature of $0.0\,°C$ and pressure $250\,kPa$.

a Calculate the number of molecules in the tyre. **[2]**

b Explain why, after the car is driven for a while, the pressure of the air in the tyre will increase. **[3]**

c Calculate the new pressure of the tyre when the temperature increases to $35\,°C$ and the volume expands to $1.60 \times 10^{-2}\,m^3$.

d The car is parked for the night and the volume, pressure and temperature of the air in the tyre return to their initial values. A small leak in the tyre reduces the pressure from $250\,kPa$ to $230\,kPa$ in the course of $8\,h$. Estimate (stating any assumptions you make):

i the average rate of loss of molecules (in molecules per second) **[2]**

ii the total mass of air lost (take the molar mass of air to be $29\,g\,mol^{-1}$). **[3]**