Questions on Thermal Energy

1. This question is about a bubble of air which is breathed out by a deep sea diver.

Write down the equation of state for an ideal gas.

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(1)

By making a suitable estimate, calculate the number of moles of air contained in the bubble which has a volume of 20 cm^3 at the surface of the sea. Assume the pressure inside the bubble is 1×10^5 Pa.

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(3)

State what would happen to the volume of this bubble if the water were colder.

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(1)

(Total 5 marks)

2. Next to the 3000-year-old Drombeg circle in Ireland is a stone-lined pit known as a Fulacht Fiadh. It is believed that this was used as a cooking place for meat caught by hunters. The pit was filled with water. Large stones were heated in a fire and then placed in the water to bring it to the boil and cook the meat.

In experiments to test this idea it was found that the water in the pit started to boil after twenty-two heated stones had been added. The total mass of the added stones was 198 kg and the mass of water was 513 kg.

Show that this gives a minimum temperature for the fire of about 900 °C.

Specific heat capacity of water	= 4200 J kg^{-1} $°C^{-1}$
Average specific heat capacity of stone	= 1100 J kg^{-1} $°C^{-1}$
Initial temperature of water	= 18 °C
Temperature of boiling water	= 100 °C

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(4)

Explain why the temperature of the fire would be higher than the calculated value.

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(2)
(Total 6 marks)

3. Two physics teachers are getting hot drinks from a drinks machine. One teacher suggests that the machine must contain a reservoir of hot water. The other teacher says that there isn't room to store water inside the machine. He suggests that the water must come from the mains water supply and be heated by a heater in the machine, as it is needed.

The teachers take the following measurements to decide who is correct.

Mass of water in cup = 0.20 kg
Room temperature = 22°C
Temperature of water in cup = 75°C
Time to fill cup = 6.0 s
(Specific heat capacity of water = 4200 J kg^{-1} $°C^{-1}$)

Calculate the energy required to heat the water for one cup.

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Energy = ...

(3)

The drinks machine is marked “2500 W”. Calculate the maximum thermal energy which the heater could supply in the time it takes to fill the cup.

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Energy = ...

(2)

Explain which suggestion is most likely to be correct.

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(1)

Heat losses were not considered. What would be the effect on the energy required to heat the water for one cup if heat losses were considered?

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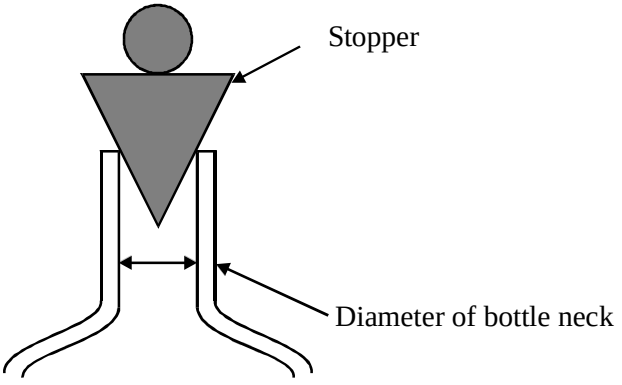
(1)
(Total 7 marks)

4. A bottle, half-full of cool, sparkling apple juice, has a special stopper which rests on the neck of the bottle and helps to prevent the juice losing its “fizz”. From time to time the stopper lifts slightly, releasing a small amount of gas, and then falls back.



The diagram shows the stopper resting on the neck of the bottle.

Draw labelled arrows on the diagram to represent the vertical components of the forces acting on the stopper as it lifts.

(2)

Show that the excess pressure of the gas in the bottle just before the stopper lifts is about 5 kPa.

Mass of stopper = 0.12 kg
Diameter of bottle neck = 1.8×10^{-2} m

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(3)

By estimating the volume and temperature of the bottle, calculate an approximate value for the quantity of gas, in moles, in the bottle just before the stopper lifts.

Atmospheric pressure = 100 kPa.

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Number of moles =.....

(5)
(Total 10 marks)