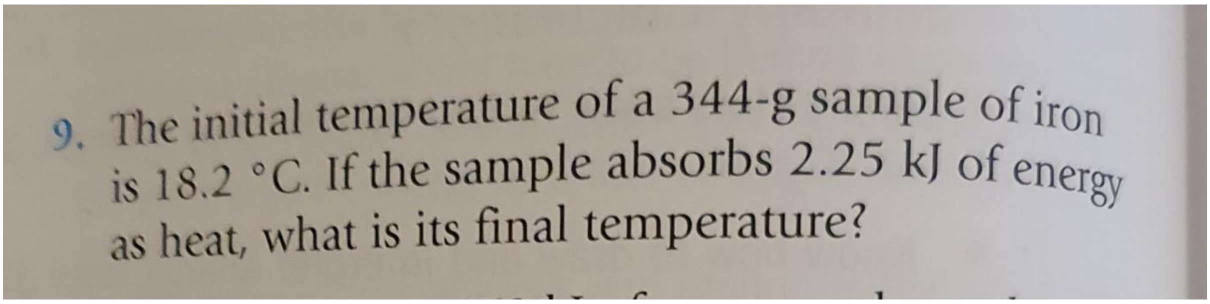
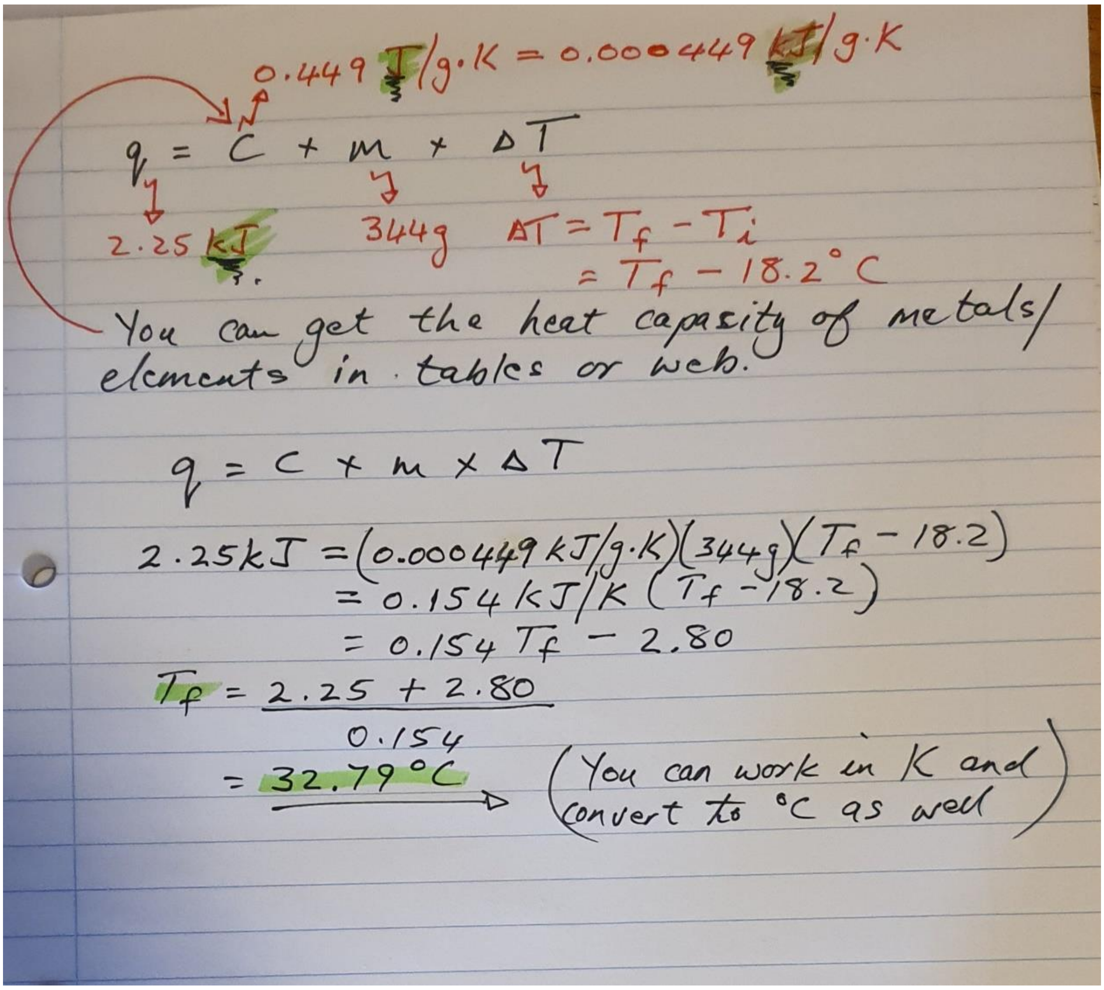
EXTRA WORKED OUT Q&A FOR STUDY UNIT 5



9. The initial temperature of a 344-g sample of iron is 18.2 °C. If the sample absorbs 2.25 kJ of energy as heat, what is its final temperature?



$0.449\ J/g\cdot K = 0.000449\ kJ/g\cdot K$

$q = C \times m \times \Delta T$

$2.25\ kJ$ $\quad 344g \quad \Delta T = T_f - T_i$

$= T_f - 18.2\ °C$

You can get the heat capacity of metals/ elements in tables or web.

$q = C \times m \times \Delta T$

$$2.25kJ = (0.000449\ kJ/g\cdot K)(344g)(T_f - 18.2)$$

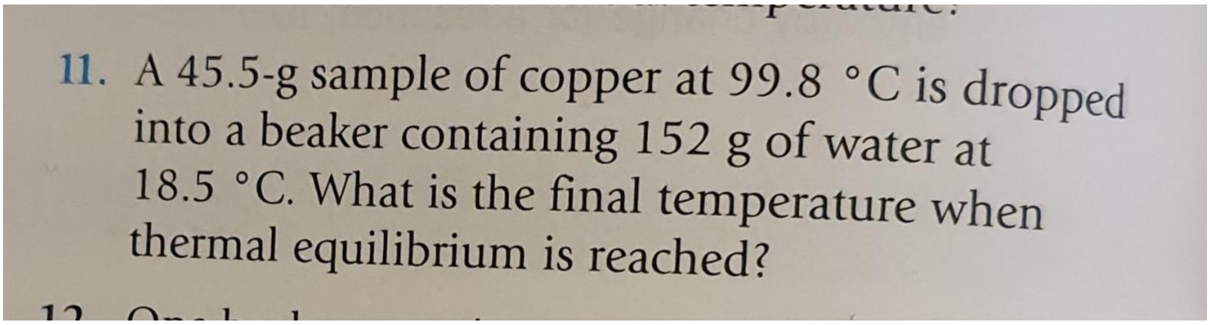
$$= 0.154\ kJ/K\ (T_f - 18.2)$$

$$= 0.154\ T_f - 2.80$$

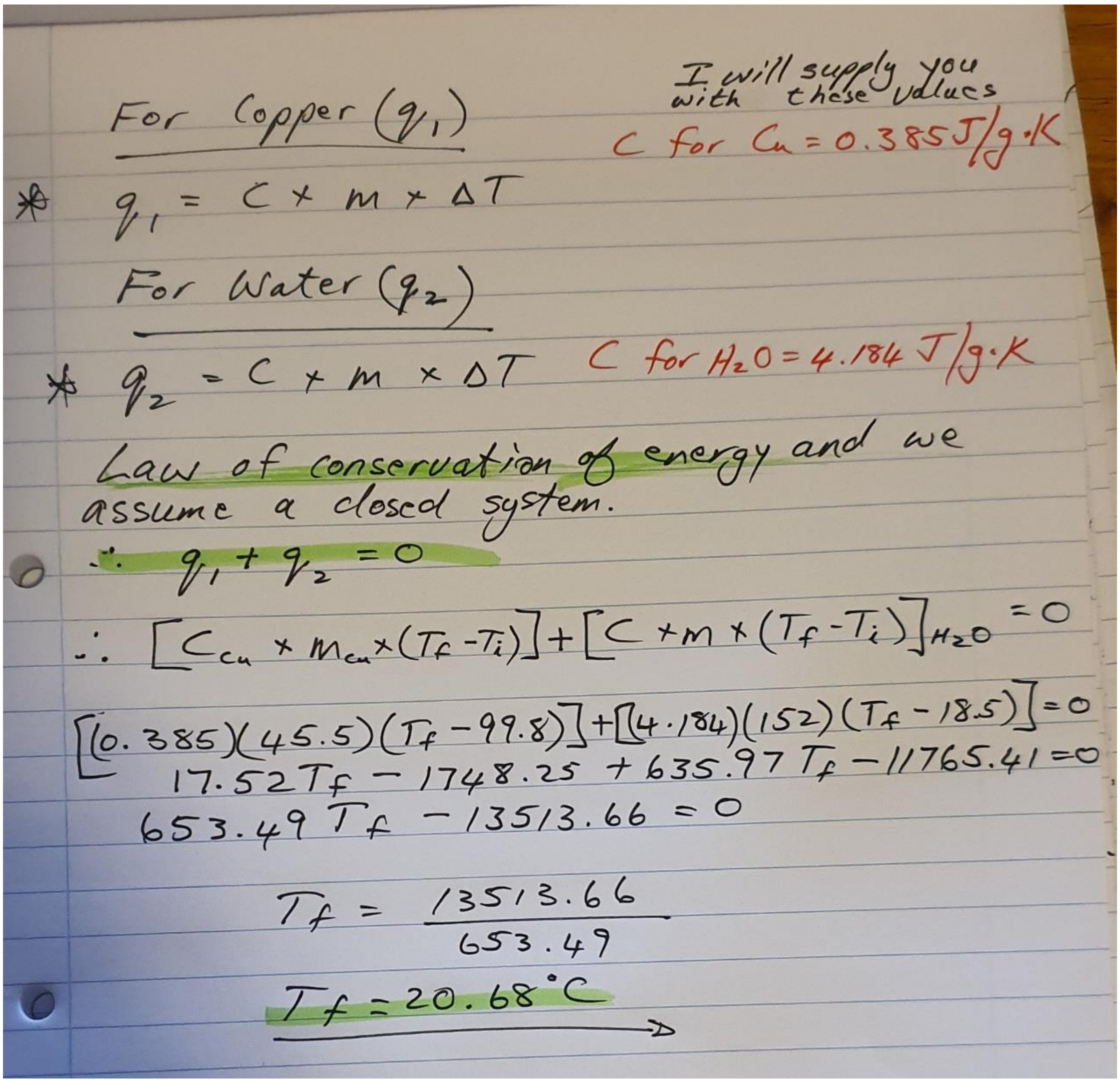
$$T_f = \frac{2.25 + 2.80}{0.154}$$

$$= 32.79\ °C$$

(You can work in K and convert to °C as well)



11. A 45.5-g sample of copper at 99.8 °C is dropped into a beaker containing 152 g of water at 18.5 °C. What is the final temperature when thermal equilibrium is reached?



For Copper (q_1)

I will supply you with these values

C for Cu = 0.385 J/g·K

* $q_1 = C \times m \times \Delta T$

For Water (q_2)

* $q_2 = C \times m \times \Delta T$ C for $H_2O = 4.184$ J/g·K

Law of conservation of energy and we assume a closed system.

$\therefore q_1 + q_2 = 0$

$\therefore [C_{Cu} \times m_{Cu} \times (T_f - T_i)] + [C \times m \times (T_f - T_i)]_{H_2O} = 0$

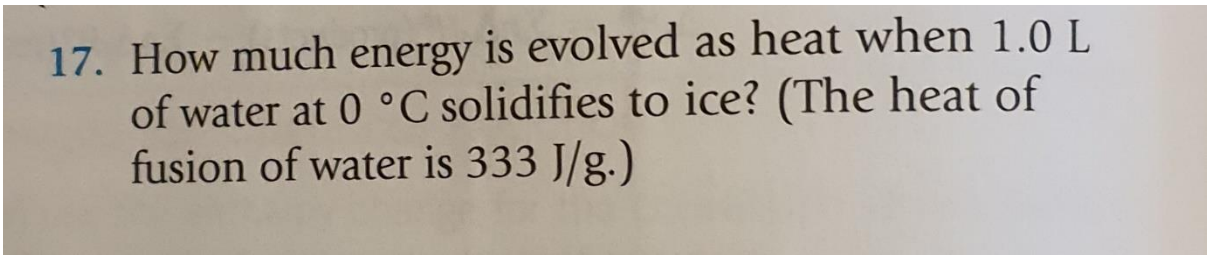
$[(0.385)(45.5)(T_f - 99.8)] + [(4.184)(152)(T_f - 18.5)] = 0$

$17.52T_f - 1748.25 + 635.97T_f - 11765.41 = 0$

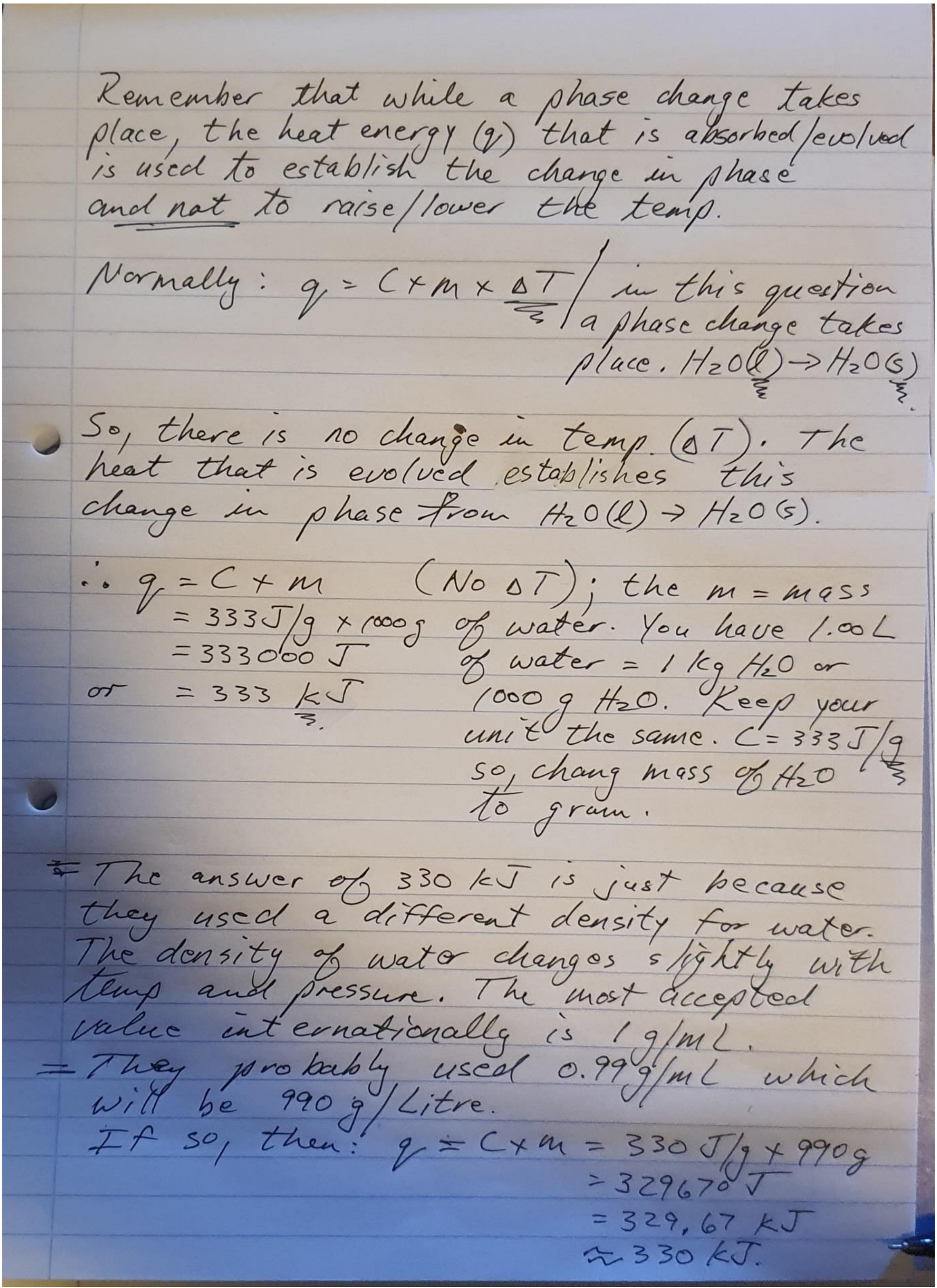
$653.49T_f - 13513.66 = 0$

$$T_f = \frac{13513.66}{653.49}$$

$T_f = 20.68°C$



17. How much energy is evolved as heat when 1.0 L of water at 0 °C solidifies to ice? (The heat of fusion of water is 333 J/g.)



Remember that while a phase change takes place, the heat energy (q) that is absorbed/evolved is used to establish the change in phase <u>and not</u> to raise/lower the temp.

Normally: $q = C \times m \times \underline{\Delta T}$ / in this question a phase change takes place. $H_2O(l) \rightarrow H_2O(s)$

So, there is no change in temp (ΔT). The heat that is evolved establishes this change in phase from $H_2O(l) \rightarrow H_2O(s)$.

$\therefore q = C \times m$ (No ΔT); the m = mass of water. You have 1.00 L of water = 1 kg H_2O or 1000 g H_2O. Keep your unit the same. $C = 333$ J/g so, chang mass of H_2O to gram.

$= 333\text{ J/g} \times 1000\text{ g}$

$= 333000$ J

or $= 333$ kJ.

= The answer of 330 kJ is just because they used a different density for water. The density of water changes slightly with temp and pressure. The most accepted value internationally is 1 g/mL.

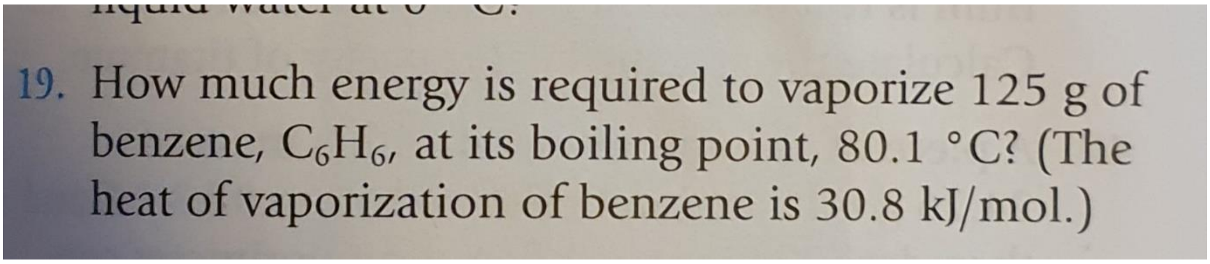
= They probably used 0.99 g/mL which will be 990 g/Litre.

If so, then: $q \doteq C \times m = 330\text{ J/g} \times 990\text{ g}$

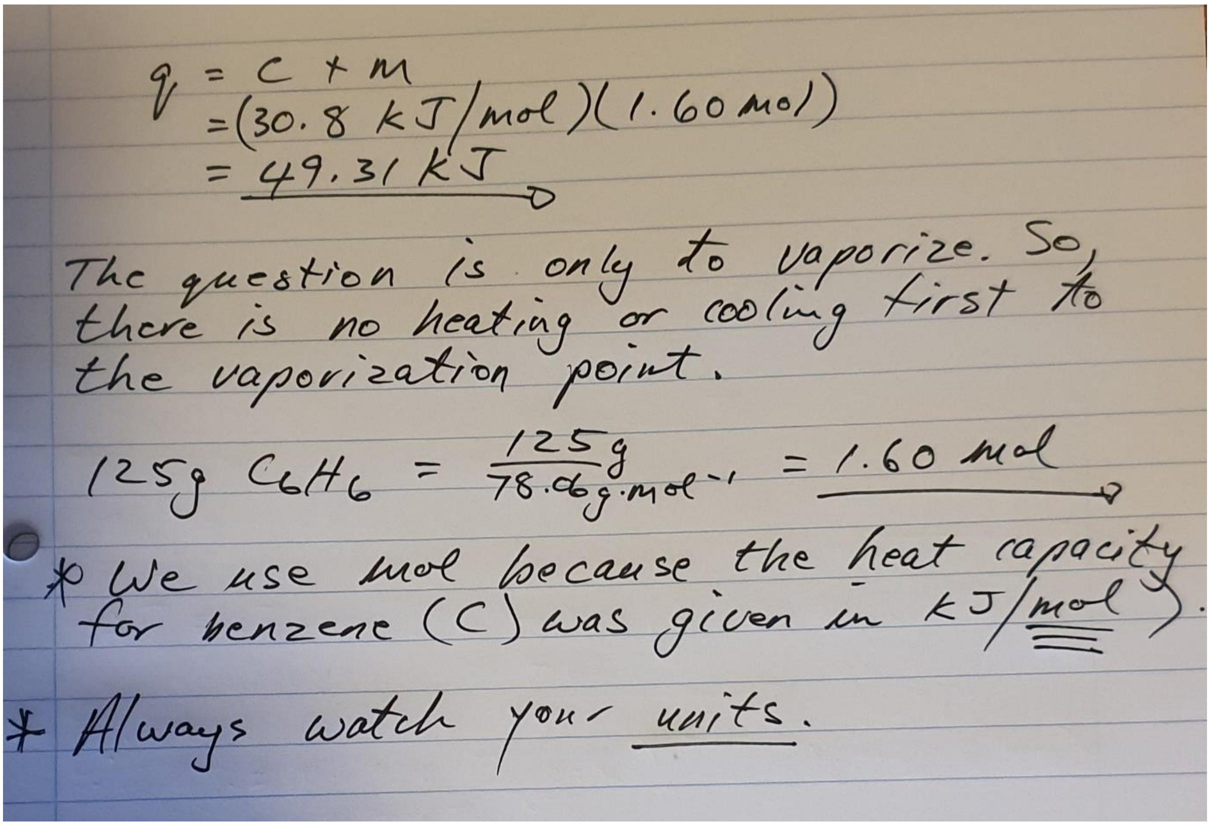
$= 329670$ J

$= 329{,}67$ kJ

≈ 330 kJ.



19. How much energy is required to vaporize 125 g of benzene, C_6H_6, at its boiling point, 80.1 °C? (The heat of vaporization of benzene is 30.8 kJ/mol.)



$$q = C \times m$$

$$= (30.8\ kJ/mol)(1.60\ mol))$$

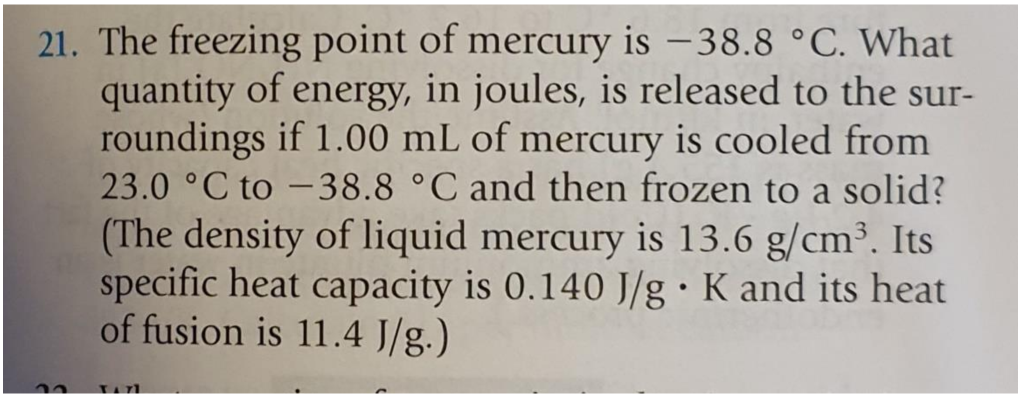
$$= \underline{49.31\ kJ} \rightarrow$$

The question is only to vaporize. So, there is no heating or cooling first to the vaporization point.

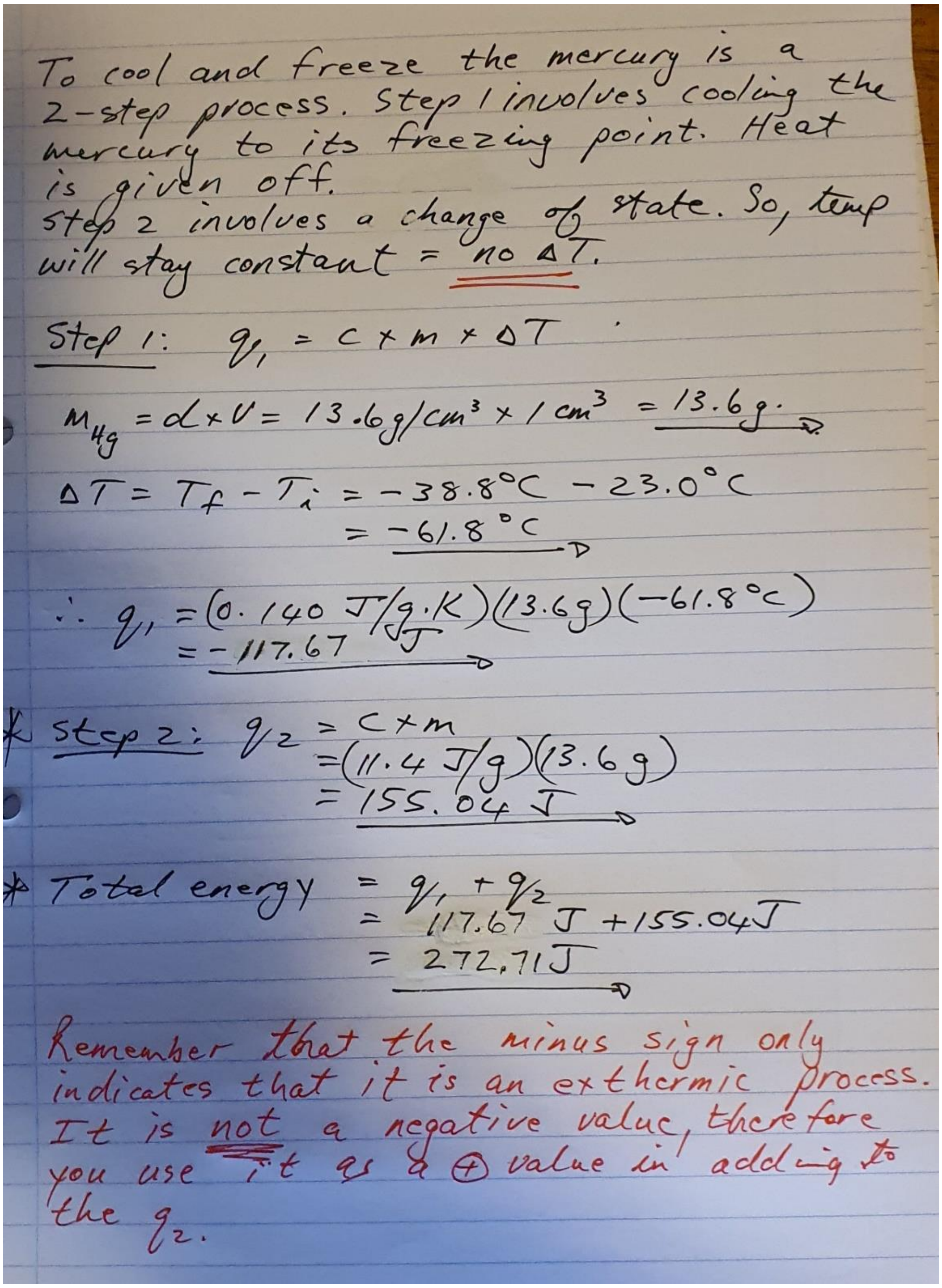
$$125g\ C_6H_6 = \frac{125g}{78.06 g \cdot mol^{-1}} = \underline{1.60\ mol} \rightarrow$$

* We use mol because the heat capacity for benzene (C) was given in kJ/<u>mol</u>).

* Always watch your <u>units</u>.



21. The freezing point of mercury is −38.8 °C. What quantity of energy, in joules, is released to the surroundings if 1.00 mL of mercury is cooled from 23.0 °C to −38.8 °C and then frozen to a solid? (The density of liquid mercury is 13.6 g/cm³. Its specific heat capacity is 0.140 J/g · K and its heat of fusion is 11.4 J/g.)



To cool and freeze the mercury is a 2-step process. Step 1 involves cooling the mercury to its freezing point. Heat is given off.
Step 2 involves a change of state. So, temp will stay constant = $\underline{\text{no } \Delta T}$.

Step 1: $q_1 = c \times m \times \Delta T$

$m_{Hg} = d \times V = 13.6\,g/cm^3 \times 1\,cm^3 = \underline{13.6\,g} \rightarrow$

$\Delta T = T_f - T_i = -38.8°C - 23.0°C$
$= \underline{-61.8\,°C} \rightarrow$

$\therefore q_1 = (0.140\,J/g.K)(13.6\,g)(-61.8\,°c)$
$= \underline{-117.67\,J} \rightarrow$

* Step 2: $q_2 = c \times m$
$= (11.4\,J/g)(13.6\,g)$
$= \underline{155.04\,J} \rightarrow$

* Total energy $= q_1 + q_2$
$= 117.67\,J + 155.04\,J$
$= \underline{272.71\,J} \rightarrow$

Remember that the minus sign only indicates that it is an exthermic process. It is not a negative value, therefore you use it as a ⊕ value in adding to the q_2.