cohesive energy exercise

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Imagine yourself to be in a room, say a typical living room or class room. You get a box with free sodium atoms (Na) and another box with free chlorine atoms (Cl). (I know, this is quite hypothetical, it wouldn't be easy to really prepare such boxes with free atoms – but let's assume...) You connect the two boxes, and let the atoms react with each other. The result is one teaspoon of rocksalt. How much has the temperature of the room increased?

I. ENERGY RELEASED BY THE FORMATION OF THE SALT

As the cohesive energy of rocksalt is given (187 kcal/mol), we know that 187 kcal is released when 1 mole of rocksalt is formed *when starting from free atoms* (this is different from starting from solid sodium and Cl_2-gas, that's why it was said not to be realistic to prepare boxes with free atoms). How much joules is that? As 1 kcal equals 4184 J, producing 1 mole of rocksalt from free atoms releases 782.4 kJ.

How much mole of rocksalt do we have? One teaspoon. You can google culinary sites, to find that this is 5-6 g. And for sure you can find the molar weight of rocksalt: 58.4 g. Therefore, 1 teaspoon is about 0.1 mole (let's work with these simple numbers).

Conclusion: producing 1 teaspoon of rocksalt from free atoms releases 78.24 kJ of energy.

II. TEMPERATURE RISE OF THE ROOM

If the temperature of the room rises, we can approximate this as a temperature rise of the air inside the room (after a while, there will be a thermal equilibrium with the walls, but let us look only at the initial minute after the salt production). To make things easier to work with, we will approximate the air by an ideal gas (If you didn't make this approximation: great! It's perfectly possible to work with the - experimental - heat capacity for air.) If an amount of energy Q is supplied to n mole of ideal gas, the temperature rise ΔT is found by:

$$Q = C_V \, n \, \Delta T \tag{1}$$

C_V is the heat capacity of an ideal gas at constant volume (the volume of the room is constant, indeed – we neglect air leaks through non-fitting doors etc.). This is a known number:

$$C_V = \frac{3}{2} R \tag{2}$$

$$= 12.5 \, \frac{J}{K \, mol} \tag{3}$$

How many moles of 'ideal gas air' is there in the room? Let's estimate the volume of the room: say the room is 4 m × 5 m, and 3 m high. That's a volume of 60 m^3. One mole of an ideal gas at room temperature takes a volume of about 24.5 litres. That makes 2449 moles of air in the room.

As we know $n = 2449$ mol and $Q = 78.24$ kJ, we find ΔT= 2.5 K.

Conclusion: producing 1 teaspoon of table salt from free atoms makes the room 2-3 degrees warmer. That's not small. . .!

If your answer is of the same order of magnitude (you might have made slightly different estimates or assumptions), then you did it right.