October 23, 2013

INTRODUCTION TO THE NOTES ON THE ARC EXPERIMENT

On the course web-page Lecture 12A presents the results of a sample ARC experiment. **ARC** stands for **A**ccelerated **R**ate **C**alorimetry which is one of the many standard experiments by which one can assess the potential of any chemical for thermal runaway. **Thermal Runaway** occurs when the self-heating rate of the sample exceeds certain limits leading to potentially hazardous situations that end in explosions.

ARC, or a similar calorimetry experiment, is designed to provide the information which is used to prevent thermal runaways. A small amount (sample) of the chemical to be investigated is stored into a chamber ('bomb'). The mass of the sample and the mass of the 'bomb' as well as their heat capacities (specific heats) are known. The 'bomb' is immersed in a thermostat, a fluid bath, the temperature of which is slowly raised as a linear function of time. Both the bath and the sample temperature are continuously recorded, as well as the derivative of the sample temperature, as a function of time. (Sometimes the pressure in the 'bomb' is also recorded). When the rate of the sample temperature rise (temperature derivative) exceeds that of the preprogramed temperature rise of the bath that point is recorded as the start of the experiment (t=0) and the temperature at that point is designated as initial temperature $T_{0.}$ In presence of exothermic reactions the sample temperature then rises as a S-shaped function of time eventually leveling at the final adiabatic temperature, T_{ad}. The maximum in the recorded temperature derivative m= (dT/dt) indicates the time t^* when the inflection point is reached when the temperature is T^*. For all samples it is important to record these values. Then, as shown in the enclosed handwritten notes, we can evaluate the activation energy, the heat of reaction and reaction order. Knowing these we can calculate our parameter δ and critical $Da\tau^*$ as studied in safe behavior of adiabatic plug flow reactors. The batch reactor (our ARC 'bomb') plays a role of the PFR and actual time t replaces space time τ. We can now predict, when our chemical is exposed to some outside temperature that is significantly higher than the normal ambient temperatures, what is the time remaining before T^* is reached. We call that time ''the point of no return". What do you think why? Also, please note the correction that has to be made when we deal with large quantities of the chemical when its container heat capacity is negligible compared to that of the chemical.

Work with your team to interpret the handwritten notes and then read Lecture 12 A.