SCIE1000, Tutorial Week 9: CSI UQ.

- This week you will work through some calculation and discussion questions relating to forensic science and alcohol degradation in post-mortem tissue samples.
- As usual, you should recognise that the broad concepts and techniques we cover are more important than the specific examples. Do not try to commit lots of facts to memory; instead, know **how** to do things, and **when** certain models and approaches are appropriate.
- You really should be making **very good** progress on your projects by now; the due date is getting very close. **The requirements for submission, including the due date and time, are very strict.** Do not leave it until the last minute!

1 Questions

In forensic cases it can be vital to identify whether alcohol (ethanol) was present prior to death, and to estimate the initial concentration accurately.

When a person dies with alcohol in their system, the alcohol degrades after death. The rate of degradation depends on factors such as temperature, exposure to air, initial concentration and the elapsed time. Because remains are typically exposed to variable preservation and storage conditions, determining pre-death blood alcohol concentrations in post-mortem tissue samples is difficult. (Also, alcohol is often a by-product of bacterial action during decomposition. Research suggests that the *vitreous humour* inside the eye is less contaminated by bacterial action, so is a good source of tissue for estimating pre-death blood alcohol concentrations.)

A paper[1] models the post-mortem level of alcohol $A(t)$ remaining in a tissue sample at time t after death using the equation $A(t) = A_0 e^{-kt}$ where A_0 is the level of alcohol present at death, and k is the rate of degradation after death. The value of k depends on factors such as storage conditions. For example, the paper shows that if tissue is stored at a temperature of 25 °C and is exposed to air, then 33% of the alcohol present at time of death will degrade by $t = 360$ hours post-mortem (that is, 15 days).

1. Assume that a post-mortem human tissue sample is stored at 25 °C and is exposed to air.
   (a) Find the post-mortem rate of degradation k of alcohol in the tissue. Also find the units of k.
   (b) Find the half-life of alcohol in post-mortem tissue samples stored under these conditions.
2. Consider the following hypothetical scenario.

   Police discover the body of a man killed in a car accident on an isolated road. Analysis of the accident scene and interviews with witnesses to his activities prior to the accident show that:
   - the man was driving the car;
   - his weight was 80 kg, and his body shape and size was 'typical';
   - the fatal accident occurred **exactly** 3 days earlier;
   - he ceased consuming alcohol 3 hours before death;
   - he commenced driving 1 hour before death; and
   - analyses of tissue samples show an alcohol concentration of 0.047%.

   The police, coroner and insurance company need to know the extent (if any) to which alcohol was a contributing factor to the accident.

[1] Ferrari *et al.*, *Kinetics of ethanol degradation in forensic blood samples*, Forensic Science International **161:2** (2006) 144–150.

(a) Assuming the temperature had been a constant 25 °C, was the man over the legal blood alcohol level of 0.05% for driving at the time of his death?

(b) Estimate his blood alcohol concentration when he commenced driving.

(c) Witnesses state that the man was a responsible and careful driver, and had consumed "between 3 and 4 standard drinks". Investigate the witness statements.

3. The above-mentioned paper demonstrates that ethanol degradation in post-mortem tissues samples is slowest at a temperature of $-10°$C and when there is no air in the storage container. Under these conditions, only 0.01% of the ethanol has degraded after 360 hours (15 days). Find the half-life of ethanol in post-mortem tissue samples stored under these conditions.

4. If you have spare time then you might like to do some work on your project.

The end