LONDON'S GLOBAL UNIVERSITY

ARTS AND SCIENCES (BASc)

Sciences and Engineering

Below are examples of questions used for a previous Sciences and Engineering test, so please disregard any references to a lecture.

In the new test, you must answer the compulsory Maths question plus one of the other three questions available.

Please note, the questions below are for demonstration purposes only and the questions in the final test may take a different format.

EXAMPLE COMPULSORY QUESTION

Here we will derive an equation to allow us to use experimental data to evaluate the change in volume (ΔV) when ice melts to form liquid water. Each part carries 4 marks and each part can be done independently from the other parts.

The gradient of the phase boundaries on a phase diagram plotting pressure *p* against temperature *T* are given by the Clapeyron equation:

$$\frac{dp}{dT} = \frac{\Delta H}{T\ \Delta V} \qquad \text{(Eq1)}$$

Here ΔH is the energy change on melting.

(a) Rearrange Eq. (1) and integrate both sides to show:

$$\int dp = \frac{\Delta H}{\Delta V}\int \frac{1}{T}\,dT \qquad \text{(Eq2)}$$

What are you assuming about ΔV and ΔH in performing this rearrangement?

(b) If the temperature is T_1 when the pressure is p_1 and T_2 when the pressure is p_2 integrate both sides of Eq. 2 to show:

$$p_2 - p_1 = \frac{\Delta H}{\Delta V}\ln\left(\frac{T_2}{T_1}\right) \qquad \text{(Eq3)}$$

(c) Simplify Eq. (3) further, by showing that $\ln\left(\frac{T_2}{T_1}\right) = \ln\left(1 + \frac{T_2 - T_1}{T_1}\right)$ and hence:

$$p_2 - p_1 = \frac{\Delta H}{\Delta V}\ln\left(1 + \frac{T_2 - T_1}{T_1}\right) \qquad \text{(Eq4)}$$

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(d) It can be shown that:

$$f(1+a) \approx f(1) + f'(1)a \qquad \text{(Eq5)}$$

where $f'(x) = df/dx$ and *a* is small..

If T_2-T_1 is small, use Eq. (5) with $a = (T_2 - T_1)/T_1$ and $f(x) = \ln(x)$ to show,

$$\ln\left(1 + \frac{T_2 - T_1}{T_1}\right) = \frac{T_2 - T_1}{T_1}$$

Using this result show Eq. (4) can be re-written as

$$p_2 = p_1 + \frac{\Delta H}{\Delta V}\left(\frac{T_2 - T_1}{T_1}\right) \qquad \text{(Eq6)}$$

(e) Experiments show that water melts at 273.15 K (0 ^{o}C) at a pressure of 101000 Pa and 269.15 K (-4 ^{o}C) at a pressure of 5.05×10^7 Pa.

If ΔH = 334 J/g use Eq. (6) to evaluate ΔV (in m^3); this is the change in volume (V_{liq}- V_{ice}) of 1 g of ice on melting. Comment on your answer.

EXAMPLE OPTIONAL QUESTIONS – you will answer one of these in the final test.

2. Suggest reasonable scientific explanations for FOUR of the following. Your explanations do not necessarily have to be correct but must be scientifically reasonable. Each part carries 5 marks.

(a) Water ice floats on water but frozen CO_2 does not float on liquid CO_2.

(b) Penitentes (ice pillars) form on high altitude snowfields illuminated by the sun.

(c) Ice skates have a narrow blade.

(d) At very low temperatures it is hard to make a good snowball.

(e) Substances give out energy when they freeze and take up energy when they melt.

(f) Ice films grow as porous layers when deposited in the extreme cold (-260 ^{o}C) and low pressures of interstellar space.

(g) Ice crystals in polar stratospheric clouds aid ozone destruction.

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3. Discuss the properties and importance of water ice on Earth and in space. You may use examples discussed in the lecture but also use examples of your own.

(20 marks)

4. "Science's most significant contribution to the modern world is the development of new materials". Explain why you agree or disagree with this statement giving examples to support your arguments.

(20 marks)