Source material for the UH part of the BASUS entrance exam

Biogenic Volatile Organic Compounds:

Biogenic Volatile Organic Compounds (BVOCs) are important precursor molecules for atmospheric aerosols. Atmospheric aerosol particles interact with solar radiation by absorbing, reflecting and scattering light and by affecting cloud properties, and aerosols thereby impact Earth's climate. BVOCs are emitted from vegetation, and in fact, almost all vegetation emits BVOCs. The emission of BVOCs from vegetation can be modelled using the following equation: $E = \varepsilon \times \gamma_T \times \gamma_L$, where E is the emission of BVOCs at prevailing temperature and light conditions, ε is the emission rate of a BVOC at standard conditions (i.e. temperature of 30 degrees Celsius, photosynthetically active radiation of 1000 μmol m^{-2} s^{-1}), while γ_T and γ_L are emission activity factors to account for instantaneous light and temperature conditions. The emission of BVOCs from vegetation without storage structures (e.g. such as resin ducts) is controlled by the production of BVOCs inside the plant. Grasses, aspens and birches are some examples of vegetation without storage structures. For BVOC emissions controlled by BVOC production, $\gamma_L = \frac{\alpha \times C_{L1} \times PAR}{\sqrt{1+\alpha^2 \times PAR^2}}$ where α and C_{L1} are constants and PAR is photosynthetically active radiation, and γ_T behaves as a function of temperature according to Fig. 1.

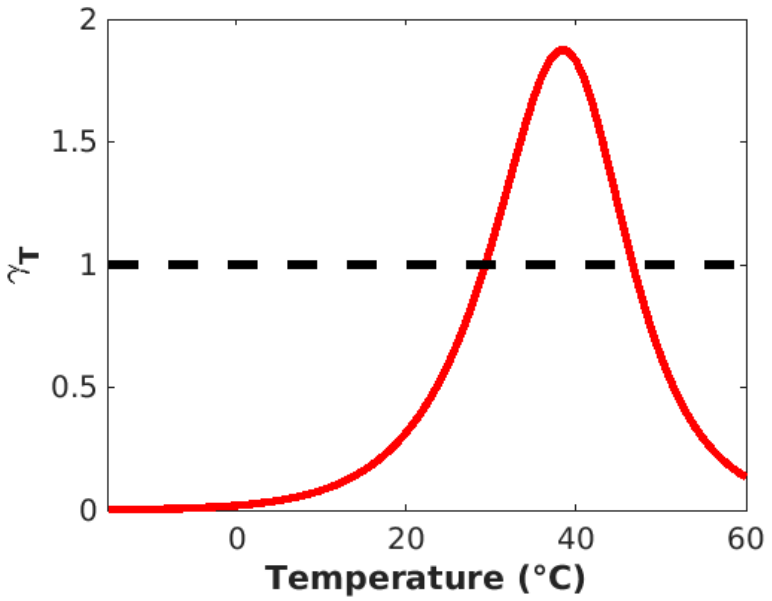

Figure 1: $\gamma_T(T)$ for BVOC emissions controlled by BVOC production.

The emission of BVOCs with rather low vapor pressures, such as e.g. monoterpenes (i.e. organic molecules containing 10 carbon atoms and which make up a large part of resin), from vegetation containing storage structures is not controlled by the production of BVOCs, but instead by the volatilization of stored BVOCs. Hence, $\gamma_T = exp(\beta \times (T - T_s))$ and $\gamma_L = 1$, where β is a constant, T_s is the standard temperature (i.e. 30 degrees Celsius) and T is the prevailing temperature. Pines and spruces are examples of vegetation with storage structures.

Greenhouse effect:
Earth receives practically all the energy it needs from the Sun. The energy comes from the Sun as short-wave electromagnetic radiation (wavelength range shown in Fig. 2). The atmosphere is mainly transparent to short-wave solar radiation and the radiation can travel to Earth's surface, where it is absorbed. The Earth's surface emits radiation as long-wave electromagnetic radiation (wavelength range shown in Fig. 2). The radiation emitted from the Sun and Earth has different wavelengths, since Earth is much cooler than the Sun. The atmosphere is not transparent to the radiation emitted from Earth. Instead this radiation is absorbed by greenhouse gases in the atmosphere, which in turn emit the radiation in all directions, including back towards Earth and towards outer space. Therefore, in addition to the short-wave radiation from the Sun, long-wave electromagnetic radiation from the atmosphere also warms the Earth's surface. The atmosphere acts like a blanket warming our planet. Thanks to this natural greenhouse effect, the Earth's surface temperature is on average +14°C, which is 32°C warmer than it would be without the greenhouse effect (-18°C). The greenhouse gases in the Earth's atmosphere include e.g. water vapour, carbon dioxide, methane and nitrous oxide. Their concentrations, especially that of carbon dioxide, have increased in the atmosphere due to human activity. Therefore, the "blanket" provided by the atmosphere is thicker as regards the movement of radiation, and the surface temperature has significantly increased compared to that of pre-industrial times.

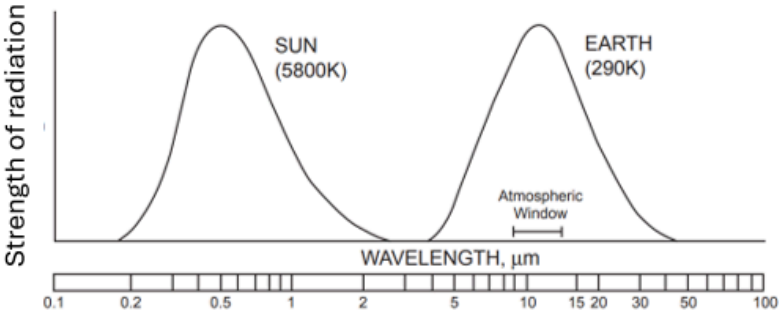

Image: Daniel Jacobs, Introduction to Atmospheric Chemistry, 1999, https://acmg.seas.harvard.edu/education/introduction-atmospheric-chemistry

Figure 2: Radiation spectrum of Sun and Earth.

It is assumed that the candidate has read and understood the following articles:

- https://scispace.com/pdf/acid-catalyzed-preparation-of-biodiesel-from-waste-vegetable-5cui7feoru.pdf (3 pages)
- https://www.acs.org/education/chemmatters/articles/save-it-for-later-batteries-keep-us-energized.html (6 pages)
- https://www.acs.org/education/chemmatters/articles/how-to-make-fashion-sustainable.html (3 pages)

- https://www.acs.org/green-chemistry-sustainability/principles/12-principles-of-green-chemistry.html (8 pages - it is not necessary to read the additional resources and examples listed)

It is further assumed that the applicant has a basic understanding of the following:

- Basic high school math, including knowledge and skills to solve e.g. percentage, fraction, logarithmic, geometric and exponential calculus, simple functions, sine and cosine calculus, and simple equations including also simple differential equations and derivations of simple functions.
- Ability to read and understand graphs and figures.
- Being able to explain the fundamental terms and concepts in physics and chemistry including e.g. force, conservation of energy, internal energy, energy transfer, work, linear, circular and wave motion, vibration and sound, electric field, electrical potential, the ideal gas law, temperature, pressure and hydrostatic pressure, heating and cooling of matter and changes in state, thermal expansion, heat capacity, energy, resistance, radiation, wavelength, frequency, the electromagnetic spectrum, speed, acceleration, potential energy, kinetical energy, friction, density, absorption and emission, energy of a photon, chemical equilibria, Le Châtelier's principle, acid base equilibria in water, pH, electronegativity, polarity, composition of an atom, octet rule, Lewis structures, common bond types in chemistry, composition of the atmosphere, and basics of organic chemistry including molecular structure, bond formation in organic chemistry, isomerism, functional groups and their influence on chemical and physical properties.
- Being familiar with and able to mathematically solve simple equations relevant to physics and chemistry such as work, potential difference, different types of energy, acid base chemistry.