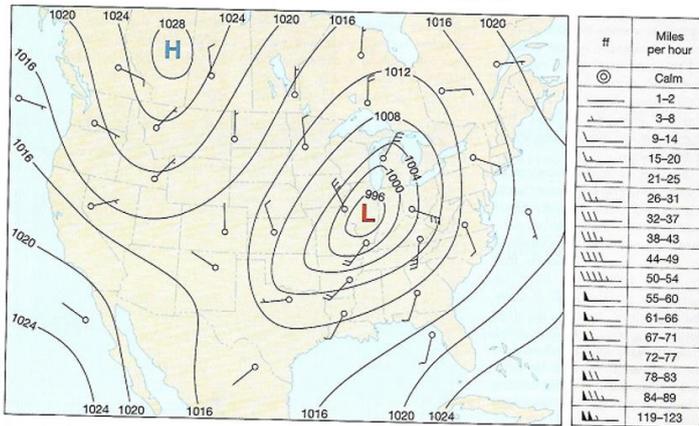


Physics Test (1 hour)

Group I (7.5 marks)

The figure below shows isobars in a synoptic chart and wind velocity vectors. The chart shows a high and a low-pressure region.



- Is the intensity of the wind consistent with the distance between isobars?
- Can we say that the wind represented is at the ground level?
- Can we say that the isobaths are referred to the sea level?

Group II (7.5 marks)

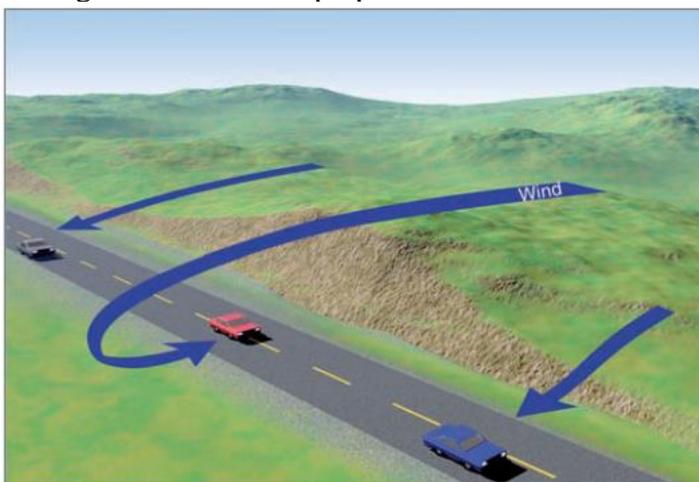
The picture below shows a “cloud hat” on the top of the Pico island in Azores a 2000 meters volcanic conic mountain.



- Explain the mechanism generating the clouds.
- Is it reasonable to expect a spiral movement of the air around the conic island?
- Seawater temperature uses to be pretty high around the island (above 20°C). Does that influence the size of the hat?

Group III (5 marks)

The figure shows winds perpendicular to a road in a hilly region.

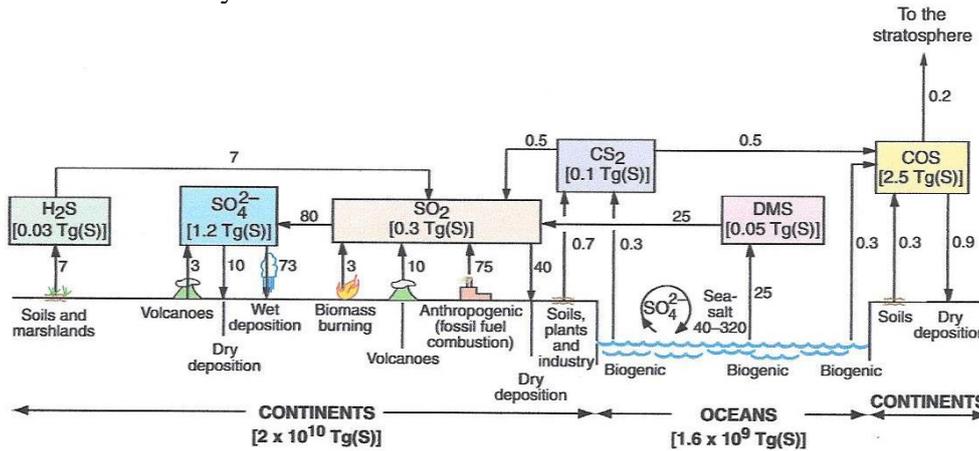


- What are the forces acting the air in this flow?
- Is it reasonable to assume that the forces applied to the cars are proportional to the square of the wind relative to each car?



Chemistry Test (1 hour)

I) The figure below is a representation of the Sulphur Cycle. Number alongside the arrows are estimates of average annual fluxes in Tg(S) per year ($Tg = 10^{12} g$); numbers in brackets are total amounts of species in the atmosphere; data is from the year 2000.



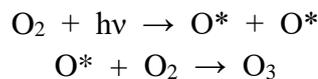
- (2.5) SO_2 is one of the main sources of acid rain. Using the data from the figure explain why acid rain caused by SO_2 in the form of H_2SO_3 is mainly a local phenomenon and not a global one.
- (3.5) Calculate the pH of rain water if a concentration of 0.12 ppm of $SO_2(g)$ is present in the atmosphere.

$$K_H = 5.4 \text{ M}\cdot\text{atm}^{-1} \quad K_{a1} = 1.7 \times 10^{-2} \quad K_{a2} = 6.4 \times 10^{-8} \quad C_g = K_H \cdot P_g$$

P_g

II) Ozone is a very important component of stratospheric and tropospheric chemistry.

- (3.5) Explain why ozone is being depleted in the stratosphere and is accumulating in the troposphere (present the equations of the main chemical reactions involved in both processes).
- (3) Suggest a reason for the reactions



to occur in the stratosphere but not in the troposphere

(O_2 bond energy = 498 kJ/mol, $N_A = 6.023 \times 10^{23}$ molecules/mol, $h = 6.626 \times 10^{-34}$ J.s, $c = 2.998 \times 10^8$ m s⁻¹)

- (2) Why tropospheric ozone is called “bad ozone”?

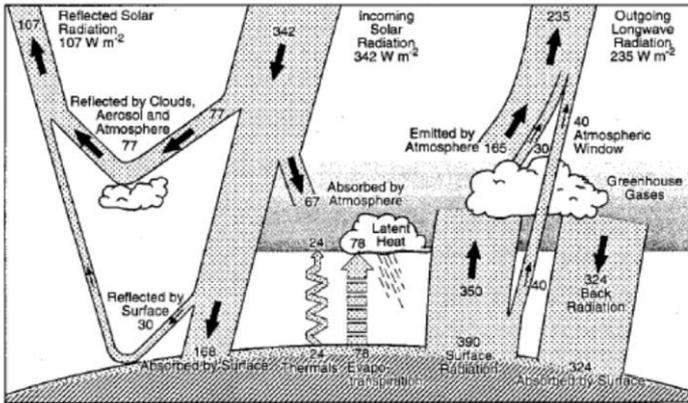
III) The concentration (mole fraction) of CH_4 in the atmosphere is 1.7 ppm.

- (3.5) Determine the total mass of CH_4 in the atmosphere (Total mass of the atmosphere = 5×10^{18} kg) (TIP: calculate the average molecular weight of air).
- (2) Determine the mass of CO_2 necessary to generate an equivalent Global Warming effect in 20 years ($GWP_{20}(CH_4) = 86$).

Thermodynamics Test (40 minutes)

GROUP I (8 values)

The picture shows the Earth's mean global energy budget.

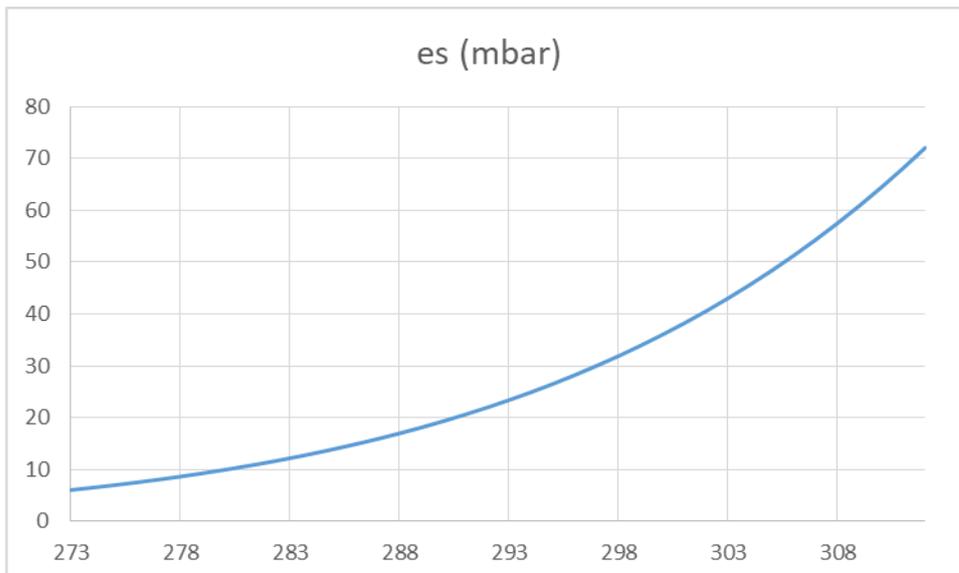


- The incoming solar radiation is considered to be 342 W.m^{-2} . Explain how this value is obtained knowing that the solar constant is approximately 1366 W.m^{-2} .
- Estimate the mean albedo of the Earth.
- Identify 2 factors that control the albedo and explain how.
- Why is it winter in January and summer in July (in Lisbon)?

GROUP II (12 values)

Consider that it is 4 AM in a winter day and that the temperature is 4°C and the relative humidity 90%.

- What is the partial pressure (in mbar) in these atmospheric conditions? Represent the point that characterizes these atmospheric conditions in the following graph that shows the Clausius-Clapeyron curve (the equilibrium vapor pressure in mbar as a function of temperature in K).



- Is it possible that mixing fog is formed in these conditions when a human breathes (37°C and 90%)? What about a dog (39°C and 90%)?
- Do you expect dew to form if the temperature falls to 2°C before the sun rises (assuming that the air is still)? Justify.
- What is the lifting condensation level at 4 AM? Do you expect clouds to form by convection if the environmental lapse rate is $2^\circ\text{C}/\text{km}$? Why?