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Department of Physics

Examination paper for FY3201 / 8902 Atmospheric Physics and Climate Change

Examination date: 11 May 2022

Examination time (from-to): 09:00-13:00

Permitted examination support material: All support materials are allowed

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OTHER INFORMATION
Only contact academic contact in case of errors or insufficiencies in the question set.

Saving: Answers written in Inspera are automatically saved every 15 seconds. If you are working in another program remember to save your answer regularly.

Cheating/Plagiarism: The exam is an individual, independent work. *Examination aids are permitted*. All submitted answers will be subject to plagiarism control. Read more about cheating ad plagiarism here: *innsida.ntnu.no/wiki/-/wiki/English/Cheating+on+exams*

Notifications: If there is a need to send a message to the candidates during the exam (e.g. if there is an error in the question set), this will be done by sending a notification in Inspera. A dialogue box will appear. You can re-read the notification by clicking the bell icon in the top right-hand corner of the screen. All candidates will also receive an SMS to ensure that nobody misses out on important information. Please keep your phone available during the exam.

Weighting: *Each correct answer is weighted 5 or 10 points. Each incorrect or blank answer is 0 points. Answers are not necessarily exact. You must choose the best or closest answer.*

ABOUT SUBMISSION

Your answers will be submitted automatically when the examination time expires and the test closes, if you have answered at least one question. This will happen even if you do not click “Submit and return to dashboard” on the last page of the question set. You can reopen and edit your answer as long as the test is open. If no questions are answered by the time the examination time expires, your answers will not be submitted.

Withdrawing from the exam: If you wish to submit a blank test/withdraw from the exam, go to the menu in the top right-hand corner and click “Submit blank”. This **can <u>not</u>** be undone, even if the test is still open.

Accessing your answer post-submission: You will find your answer in Archive when the examination time has expired.

i Help Sheet

i Periodic table

1 FY3201_V2022_Radiation_1

(5 pts.) A parallel beam of visible radiation at a single wavelength is passing vertically upward through a layer of 1 km thick. The layer contains a homogeneous gas with a density ρ_a of 0.03 kg m^{-3} with an absorption coefficient k=0.5 m^2 kg^{-1} and a zero scattering coefficient. The absorption coefficient is zero outside of this layer. What is the optical thickness of the layer?

Select one alternative:

- 3
- -15
- -1
- 15
- 0.015
- -0.015

Maximum marks: 5

2 FY3201_V2022_Radiation_2

(5 pts) At a different wavelength, the optical thickness of a layer is 5 for a vertical collimated beam, what is the transmission of the layer for this beam?

Select one alternative:

- 0.7%
- 1.5%
- 20%
- 13.5%

Maximum marks: 5

3 FY3201_V2022_Radiation_4

(5 pts) At what latitude and during what season is the daily-averaged insolation (amount of energy received from the Sun) at the top of the atmosphere the greatest?

Select one alternative:

- North pole on June 21
- Equator on Jan. 5
- South pole on Dec. 21
- Equator at Equinox

Maximum marks: 5

4 FY3201_V2022_Radiation_5

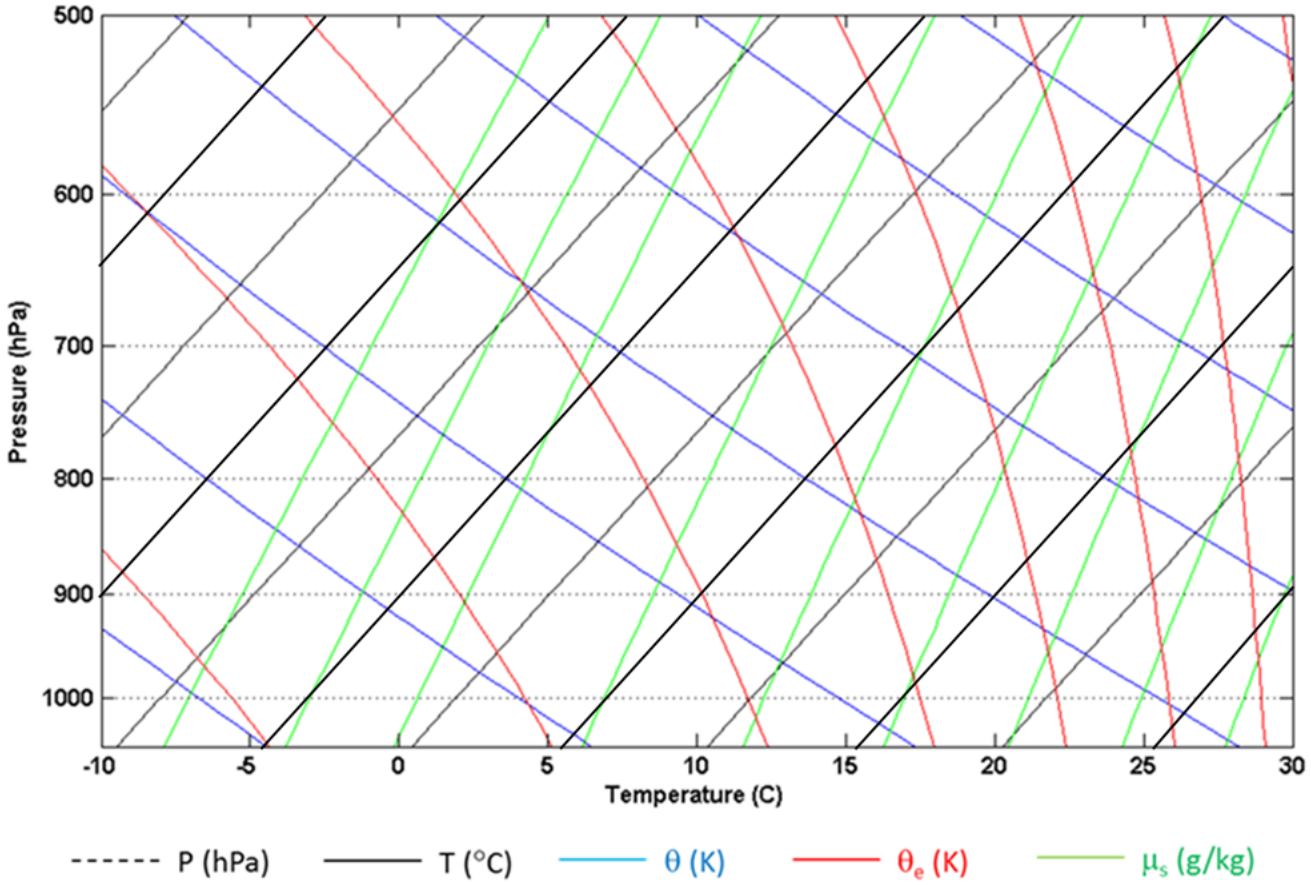
(5 pts) On a spacecraft, one only has radiation as a cooling mechanism. A spacecraft's thin, rectangular,10 m^2 solar panel is inclined at an angle of 30^o to the direct solar beam (the direction toward the Sun). The panel has an albedo for solar radiation of 0.1 and an emissivity for thermal infrared radiation of 0.9. If the panel is such a good heat conductor that both its faces always have equal temperature, calculate the temperature of the solar panel at radiative equilibrium if the total solar irradiance on the panel is 1367 Wm^{-2}.

Select one alternative:

- 331 K
- 300 K
- 0 ^oC
- 280 K

Maximum marks: 5

5 FY3201_V2022_Meteorology_Graphs



In the Skew-T log-P diagram, an air parcel at a pressure of 1000 hPa has a temperature T=20 ^{o}C (Two part question)

a) (5 pts) If the parcel has a dew-point temperature of T_D=5 ^{o}C:
Estimate the pressure at the Lifting Condensation Level (LCL)

550 hPa | 900 hPa | 750 hPa | 850 hPa | 800 hPa

b) (5 pts) A parcel at 1000 hPa has a dew point temperature of 20 ^{o}C and its temperature is also 20 ^{o}C
Estimate the temperature of the air parcel when it is lifted from 1000 hPa to 600 hPa.

-10 C | 0 C | 5 C | -20 C | -5 C

Maximum marks: 10

6 FY3201_V2022_Spectroscopy_1

(5 pts) At a wavelength of 500 nm, the scatter from a 50 nm radius particle is approximately:
Select one alternative:

- Resonant scatter
- Rayleigh Scatter
- Mie Scatter
- Predominantly forward scatter
- Forms a rainbow

Maximum marks: 5

7 FY3201_V2022_Spectroscopy_2

(5 pts) For light at a wavelength λ of 4300 nm in a dry isothermal atmosphere at T_o=275 K with a surface pressure P_o of 1000 hPa, at what altitude does the natural line width α_N equal the Lorentz, collision broadened line width γ_L.
Select one alternative:

- 100 km
- 80 km
- 50 km
- 30 km

Maximum marks: 5

8 FY3201_V2022_Spectroscopy_3

(5 pts) Molecular nitrogen (N_2) does not absorb infrared dipole radiation to make vibrational transitions because:

Select one alternative:

- The dipole moment of N_2 is perpendicular to dipole radiation
- N_2 actually does absorb infrared dipole radiation to make vibrational transitions
- N_2 has no permanent dipole moment
- N_2 only makes rotational transitions at longer wavelengths instead of vibrational transitions.

Maximum marks: 5

9 FY3201_V2022_Spectroscopy_4

(5 pts) The average surface temperature of Venus is a balmy 480°C. At what wavelength is the planet's spectral irradiance emission greatest?

Select one alternative:

- 10000 nm
- 6040 nm
- 15000 nm
- 3850 nm

Maximum marks: 5

10 FY3201_V2022_Spectroscopy_5

(5 pts) Carbon dioxide is an important absorbing gas. Two fundamental wavelengths at which carbon dioxide absorbs are 4300 nm and 15000 nm. Absorption at these wavelengths is associated with excitation into an upper vibrational (and rotational) level. Is it possible for an average collision to excite these energy levels at atmospheric temperatures of 300 K?

Select one alternative:

- Yes for 15000 nm, No for 4300 nm
- Yes
- No for 15000 nm, Yes for 4300 nm
- No

Maximum marks: 5

11 FY3201_V2022_Dynamics_1

(5 pts) The geostrophic wind results from a balance between:

Select one alternative:

- Coriolis force and centripetal force.
- centripetal force, pressure gradient force, and Coriolis force.
- pressure gradient force and Coriolis force.
- pressure gradient force, Coriolis force, and friction

Maximum marks: 5

12 FY3201_V2022_Structure_1

(5 pts) The _____ and the _____ are unstable layers of the atmosphere.
Select one alternative:

- troposphere, ionosphere
- stratosphere, thermosphere
- mesosphere, troposphere
- mesosphere, cryosphere

Maximum marks: 5

13 FY3201_SV022_Thermodynamics_1

(5 pts) Which of the following is true of a parcel of air but not true of the environment.
Select one alternative:

- consists of different air molecules at each level
- changes temperature with altitude at approximately the dry or moist adiabatic rates
- temperature values differ erratically (that is, randomly) from one level to the next
- humidity values differ erratically (that is, randomly) from one level to the next

Maximum marks: 5

14 FY3201_V2022_Thermodynamics_2

(5 pts) Which of the following would **NOT** be true concerning the temperature change taking place in a parcel of dry air moving in an atmosphere whose temperature profile is equal to the dry adiabatic lapse rate.

Select one alternative:

- condensation does not occur during the process
- the parcel does not gain or receive heat from its surroundings
- the temperature falls as the parcel rises
- the temperature rises as the parcel rises

Maximum marks: 5

15 FY3201_V2022_Thermodynamics_3

(5 pts) In the movie *The Day After Tomorrow*, the premise was that cold air in the mesosphere would descend to the surface, normally at 1000 hPa and 288 K, and freeze everything. Apparently an atmospheric scientist pointed out their mistake, and in later versions you can see they dubbed in “stratosphere” instead of “mesosphere”. If straosphereic air with a temperature of 270 K at 50 km, where the pressure is 0.8 hPa, were to descend adiabatically to the surface, what would its temperature be?

Select one alternative:

- 1712 K
- 6385 K
- 3.5 K
- 2070 K
- 13 K

Maximum marks: 5

16 FY3201_V2022_Ozone_1

(5 pts) In which layer of the atmosphere is ozone the major species?
Select one alternative:

- Stratosphere
- Mesosphere
- Thermosphere
- Troposphere
- Exosphere
- None of the above

Maximum marks: 5

17 Fy3201_V2022_Water_Vapour_1

(5 pts) Commercial passenger aircraft must maintain a cabin pressure of 756 hPa at flight level. Usually, the cabin is at a temperature of 20 Celsius at flight level and maintains this temperature as the plane lands. However, the cabin pressure equilibrates to the outside pressure once the outside pressure is above 756 hPa. If the plane lands at sea level (P=1000 hPa), what is the maximum the relative humidity (in percentage) the cabin can be when at flight level to prevent fog forming in the cabin as it lands.
Select one alternative:

- 5%
- 75%
- 25%
- 100%
- 50%

Maximum marks: 5

18 FY3201_V2022_Water_Vapour_2

(5 pts) A desert site has a temperature of 38 ^{o}C and a relative humidity of 14%. At the same time, an arctic site has a temperature of -2 ^{o}C and a relative humidity of 98%. If both sites are at 1000 hPa, which site has the highest density of water vapour in the air.

Select one alternative:

- The arctic has a higher density of water vapour
- The arctic has a higher mass mixing ratio than the desert since the air is more dense
- The desert has a higher density of water vapour
- The two sites have an identical amounts of water vapour

Maximum marks: 5

19 FY3201_V2022_Composition_1

(***10 pts***) For an isothermal atmosphere at To=288 K and a surface pressure of 1000 hPa, how much does the total mass of ***carbon*** in the atmosphere increase as the carbon dioxide volume mixing ratio (ν) changes from 350 to 400 parts per million by volume (ppm). You may take the mixing ratio of carbon dioxide to be constant in altitude up to 80 km, above which it is zero. (Answers are in giga-tonnes, Gt = 10^9 tonnes, where 1 tonne = 1000 kg)

Select one alternative:

- 10 Gt
- 2 Gt
- 100 Gt
- 400 Gt

Maximum marks: 10