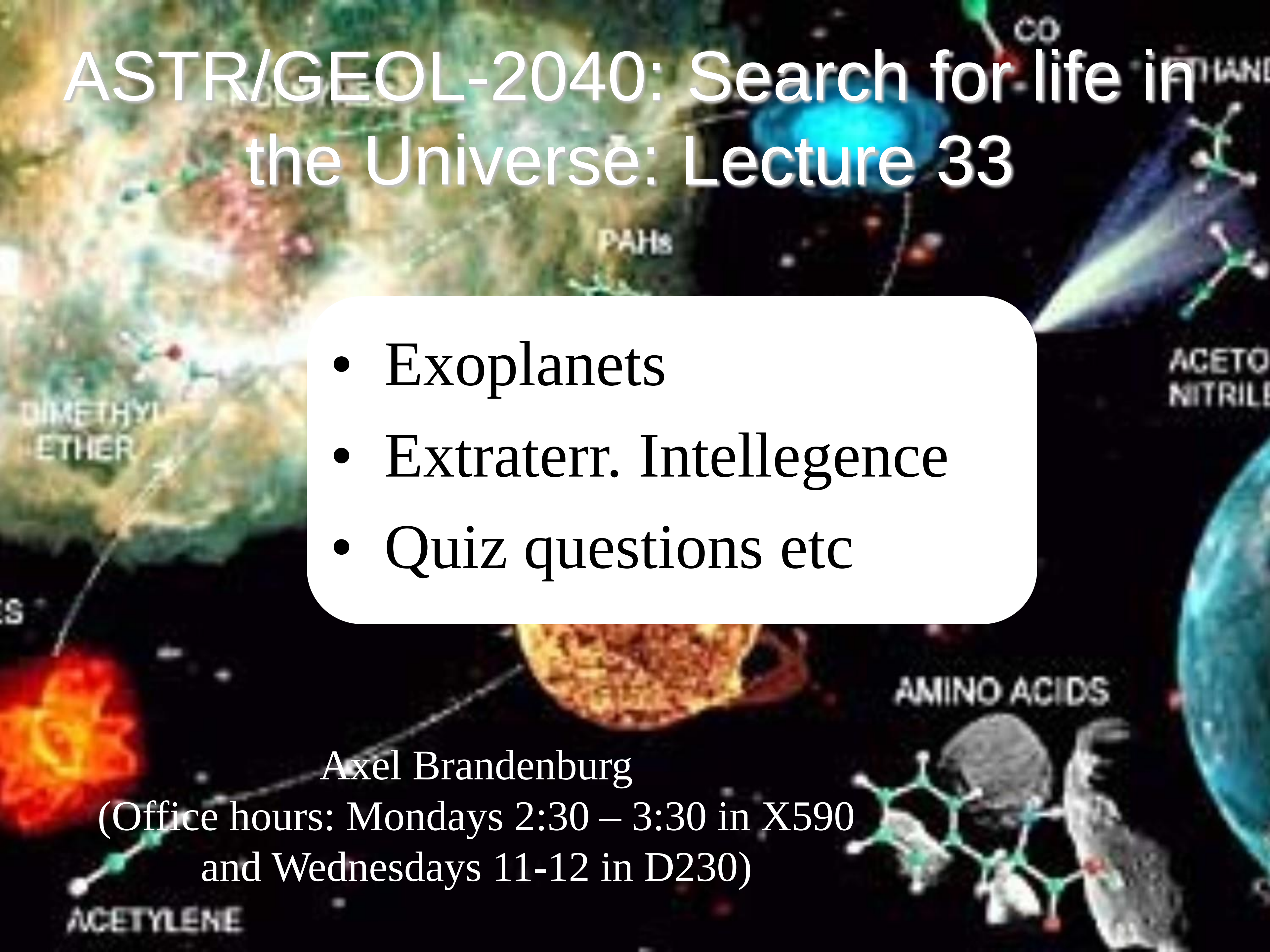
ASTR/GEOL-2040: Search for life in the Universe: Lecture 33



- Exoplanets
- Extraterr. Intellegence
- Quiz questions etc

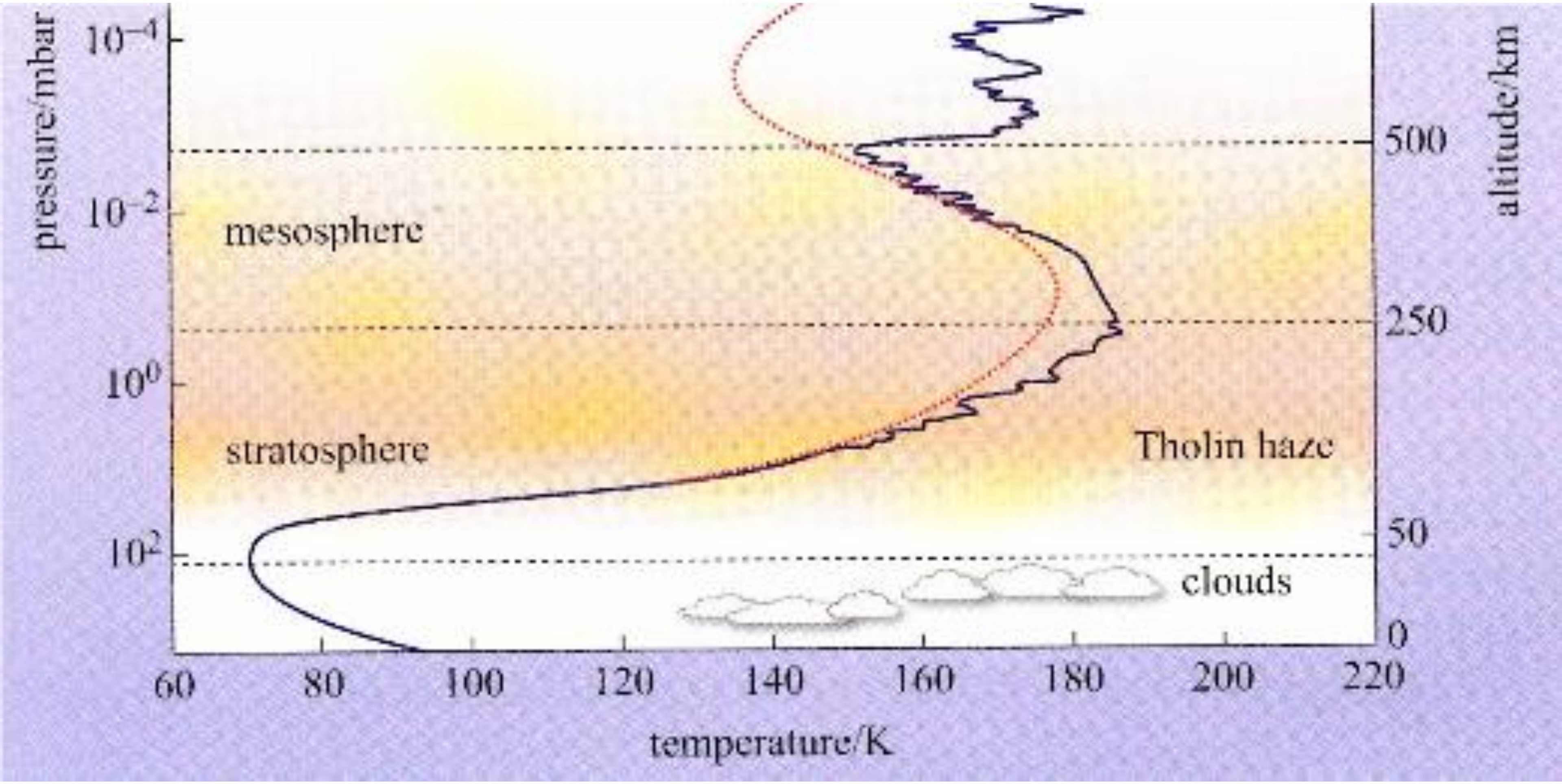
Axel Brandenburg
(Office hours: Mondays 2:30 – 3:30 in X590
and Wednesdays 11-12 in D230)

The next two weeks

- Review Quiz #2 model solutions (D2L)
- HW7 on Wednesday, due Dec 8
  - only the 5 best ones count
- How to find life on exoplanets
  - Chapter 8, pp. 261 – 280
- How to find extraterrestrial intelligence
  - Chapter 9, pp. 281 – 302
- Review of all material for the final

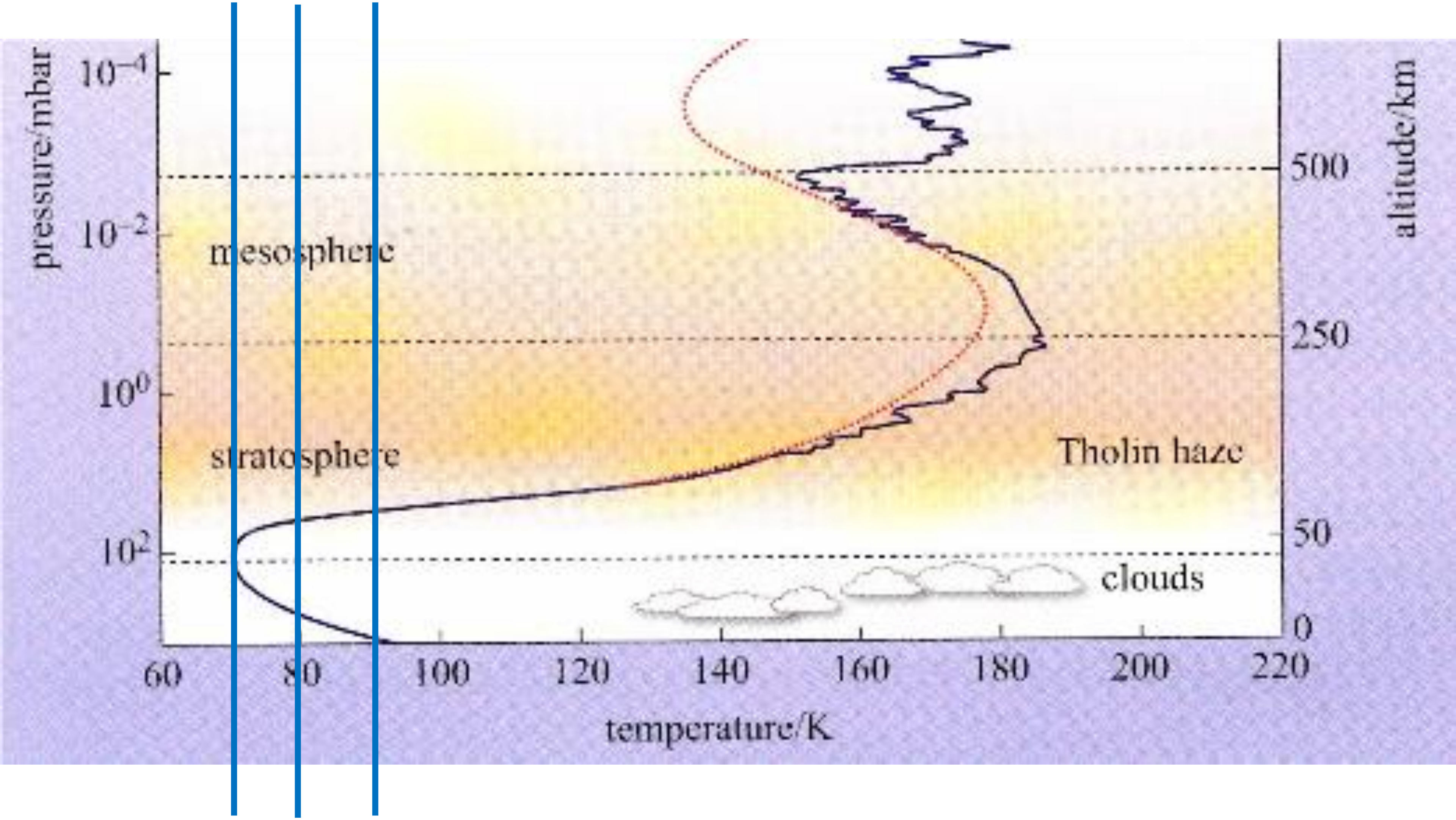
(a) Mark the points on the black line on the left plot where the temperature is 90 K (two points), 80 K (two points), and 70 K (only one point).

See the blue points in the figure above. [2pts]

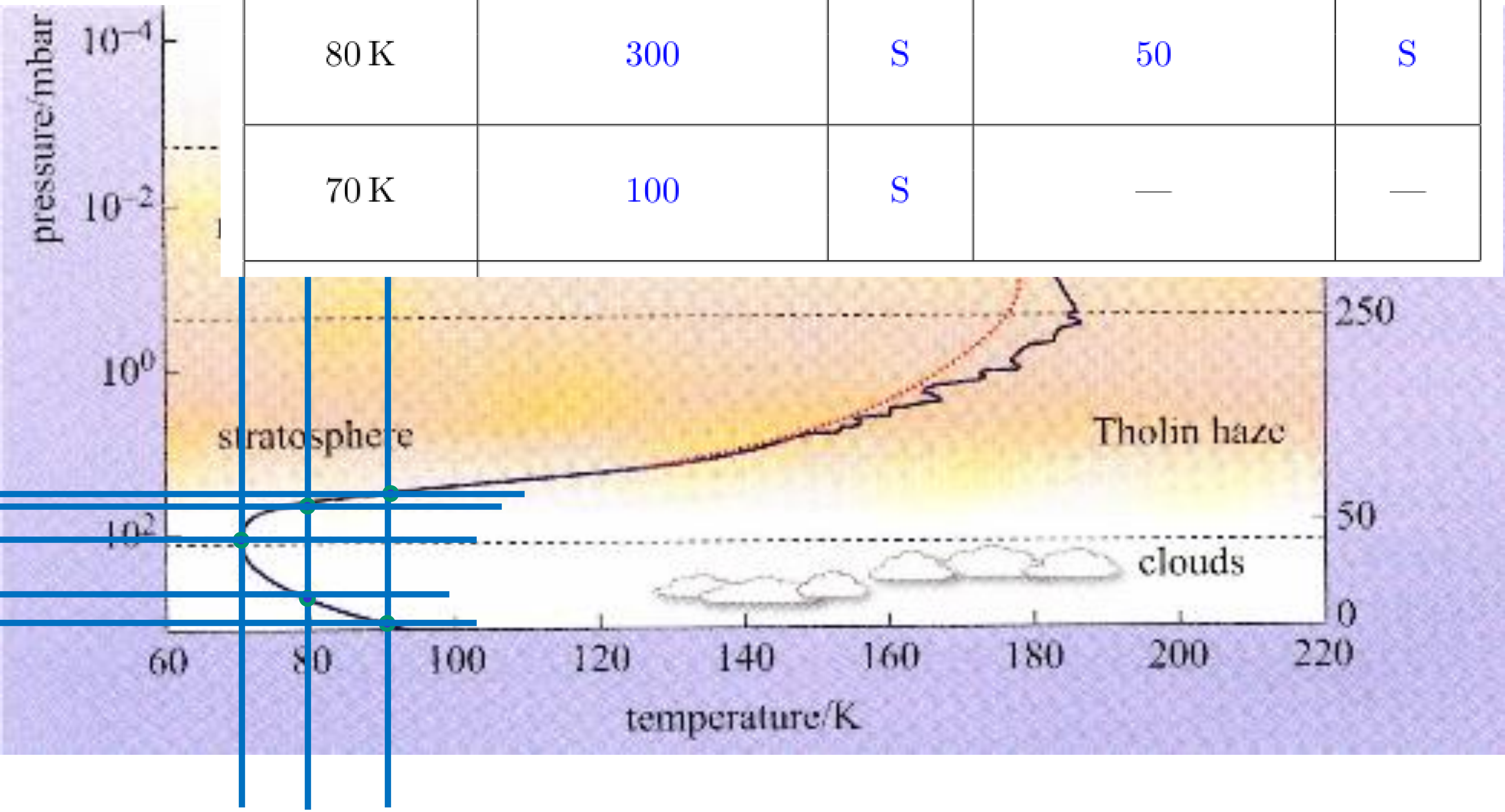


(b) Read off the corresponding pressures on each of the five points and write them in the empty fields in Table 1.

See the blue numbers in the table below. [2pts]

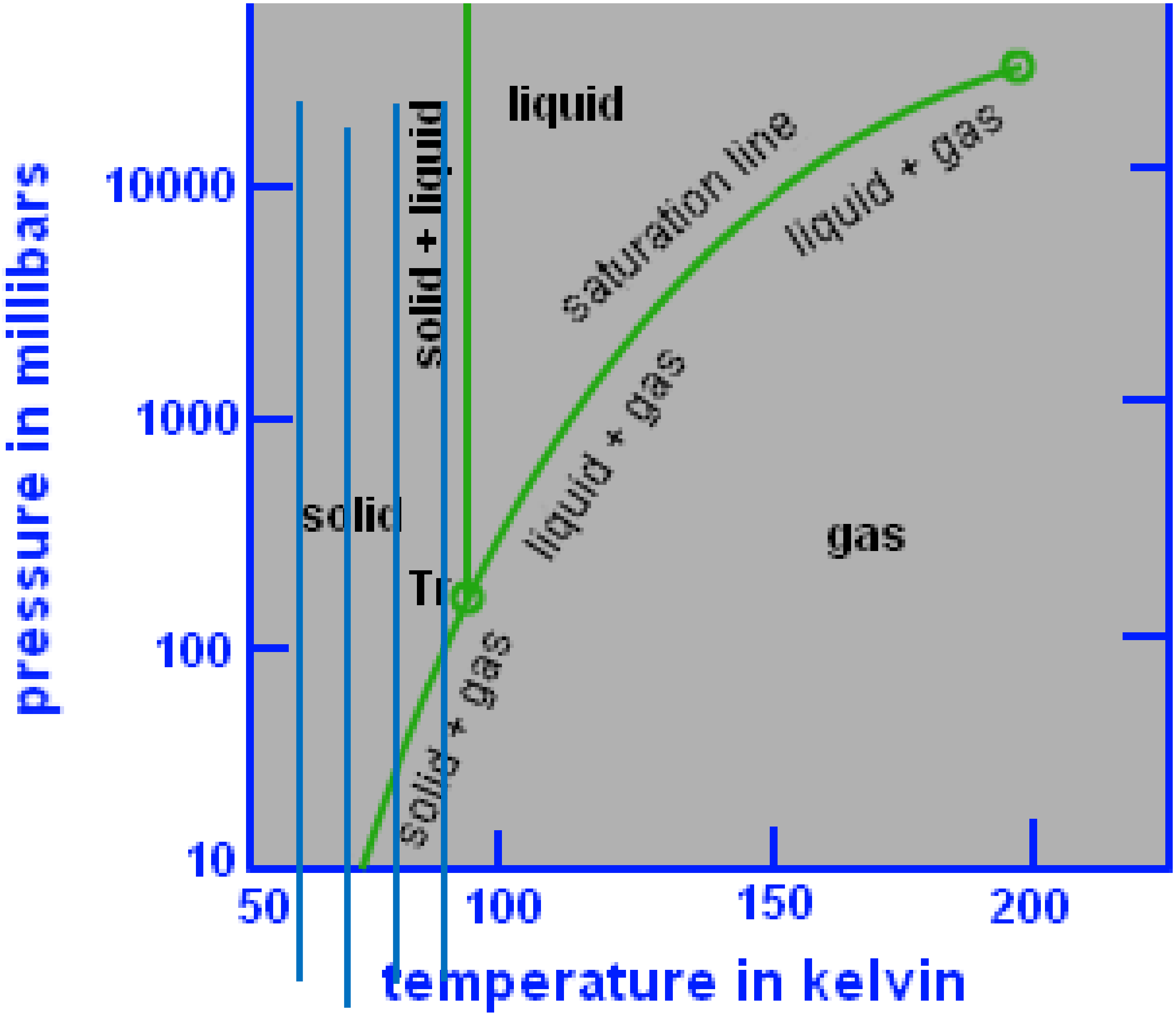


temperature	pressure (1st point)	phase?	pressure (2nd point)	phase?
90 K	1000	S	30	G
80 K	300	S	50	S
70 K	100	S	—	—



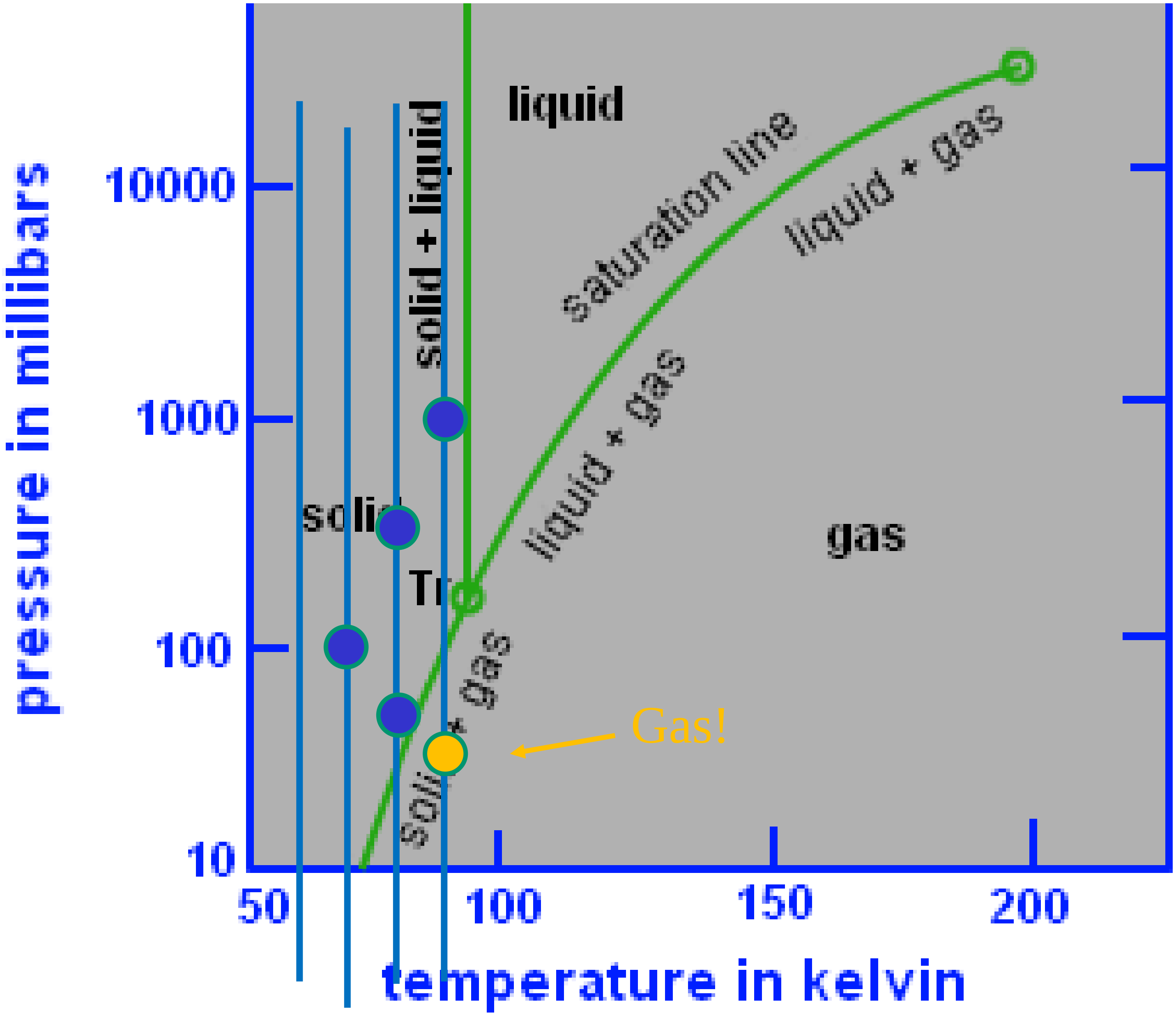
(c) Mark all the five points in the phase diagram above with dots.

See the blue points. [2pts]

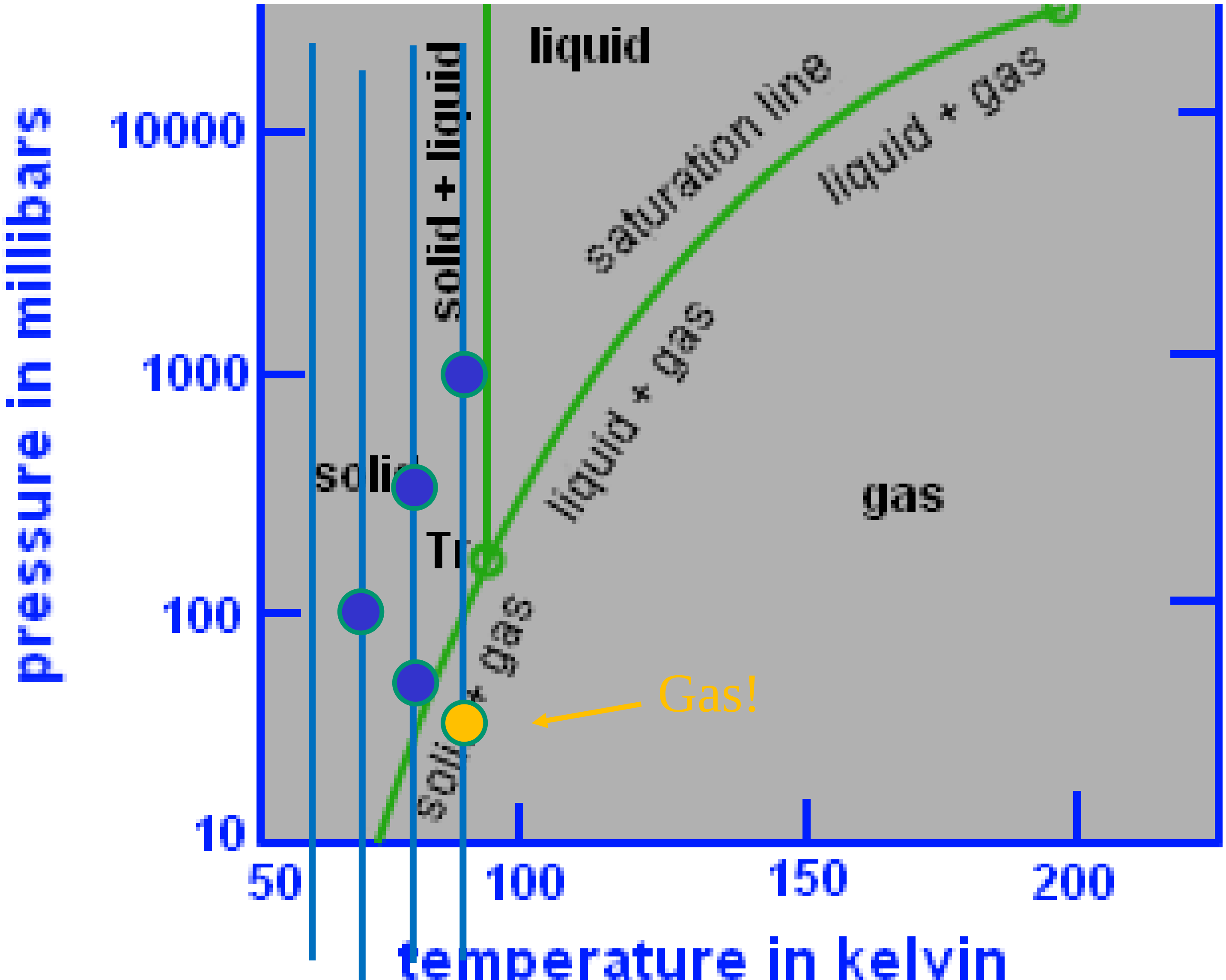


(c) Mark all the five points in the phase diagram above with dots.

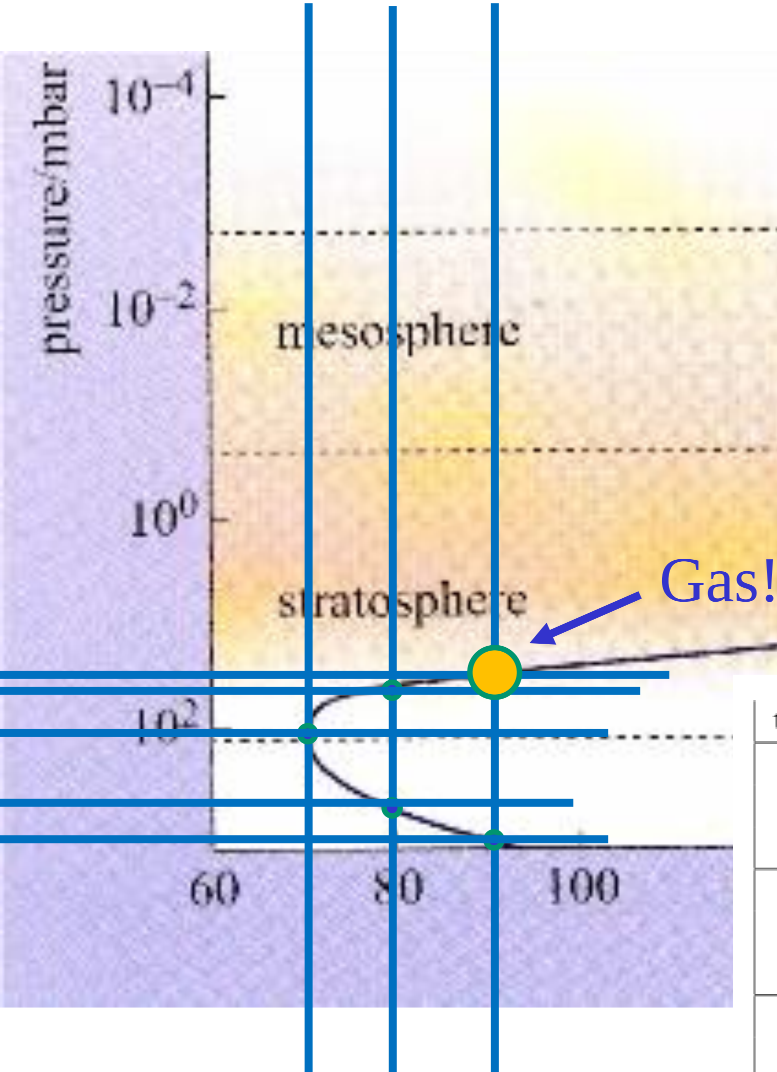
See the blue points. [2pts]



(d) Determine the phase for all five points. Write the corresponding answer in the five corresponding fields of Table 1. Use S for solid, L for liquid, and G for gas.
See the blue and orange points. [2pts]



(e) Where in the atmosphere do you expect methane in the gas phase?
In the upper layers which is denoted by "Tholin haze", see the organge dot in the figure below. [2pts]



temperature	pressure (1st point)	phase?	pressure (2nd point)	phase?
90 K	1000	S	30	G
80 K	300	S	50	S
70 K	100	S	—	—

Life elsewhere in the Universe?

- To many: most important question…
  - Profound religious & philosophical implications
  - Cannot answer (right now)
- But can pose & answer related questions
  - What can science tell us?
- One of the early approaches:
  - Number N of civilizations in our galaxy broadcasting their existence into space

Life elsewhere in the Universe?

- Drake's equation: $N = R_b\, t$

Rate (number per unit time)
at which broadcasting civilizations
appear in our galaxy

Time over
which they
broadcast

- N = ? (at least 1)   = us on Earth
- t = ?   > 50 yr … 100 yr
- $R_b > 0.02\ \mathrm{yr}^{-1}$

The Drake Equation.

$$N = R^{*} \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

The number of civilisations in our galaxy in which communication might be possible.

The average rate of star formation per year in our galaxy

The fraction of stars with planets

The average number of planets that can potentially support life (per star with planets.)

The fraction that can go on to support life.

The fraction that can go on to support intelligent life.

The fraction of civilisations that develop a technology detectable from space.

Length of time such civilisations release detectable signs into space.

Drake (1960)

- $R^* = 1\ \mathrm{yr}^{-1}$
- $f_\mathrm{p} = 0.2 \ldots 0.5$
- $n_\mathrm{e} = 1 \ldots 5$
- $f_\mathrm{l} = 1$
- $f_\mathrm{i} = 1$
- $f_\mathrm{c} = 0.1 \ldots 0.2$
- $L = 10^3 \ldots 10^8$
- $N = 10^3 \ldots 10^8$

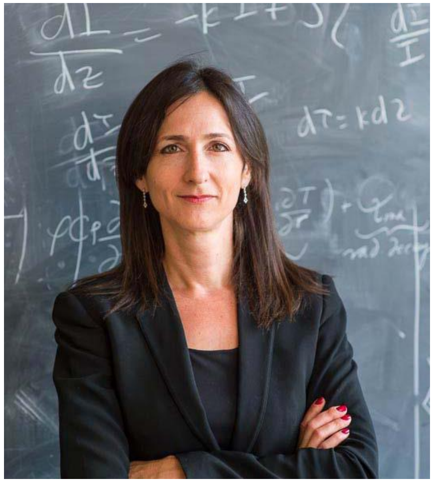
Nowadays: more accuracy

- $R^* = 1\ \mathrm{yr}^{-1}$
- $f_\mathrm{p} = 0.4$
- $n_\mathrm{e} = 0.005$
- $f_\mathrm{l} = 1$
- $f_\mathrm{i} = 1$
- $f_\mathrm{c} = 0.1 \ldots 0.2$
- $L = 10^3 \ldots 10^8$
- $N = 10^3 \ldots 10^8$

Psychology and sociology:
choose not to broadcast…

Planets with biosignatures

- N^* = number of M stars in sample
  = 30,000
- F_{Q} = fraction of quiet stars = 0.2
- F_{HZ} = rocky planets in HZ = 0.15
- F_{O} = observable = 0.001
- F_{L} = fraction with life = 1
- F_{S} = fraction with spectroscopic signatures = 0.5
- N = 2



Sara Seager

Back to exoplanets what can we observe?

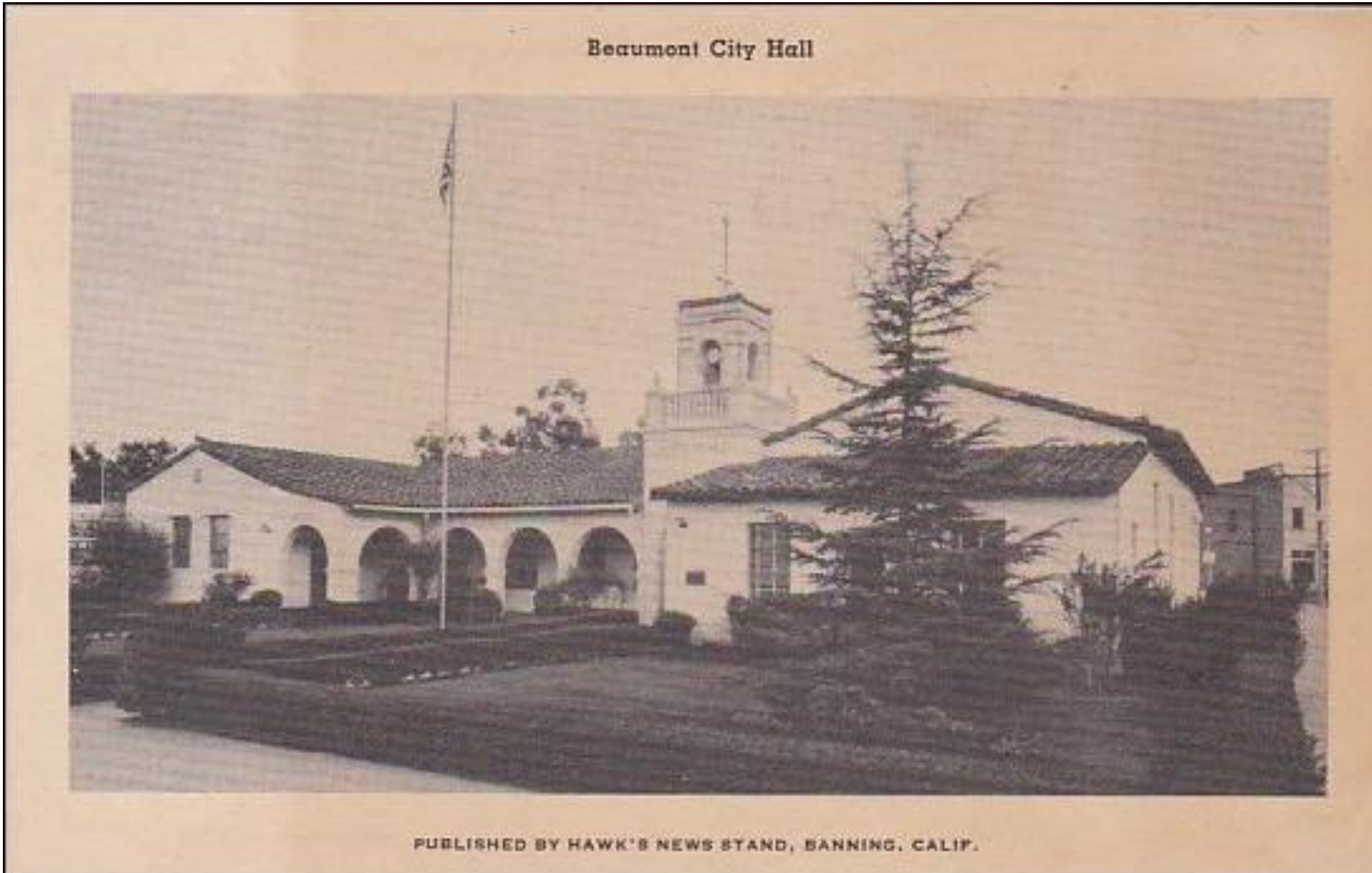
- Potential for habitability
  - Oceans, land/ocean ratio, clouds, seasons
- Surface/subsurface life?
- Eventually: atmospheric composition
  - Abundance & combination of gases

How to find biospheres

- Galileo: find life on Earth
  - fly-by on Earth (→ Challenger disaster)
- Near infrared spectrometer (NIMS)
- Large amount of O_3
  - Hard to explain abiologically
  - Also CH_4: this, together with O_3, important
  - Readily oxidized to give…


TODAY'S AIR QUALITY IS /
LA CALIDAD DEL AIRE HOY
HIGH OZONE WATCH /
AVISO DE OZONO ALTO
COMM. STEVE RADACK
HARRIS COUNTY
COURTHOUSE ANNEX 19
COMMISSIONER STEVE RADACK
CONSTABLE PHIL CAMUS
JUSTICE OF THE PEACE
COUNTY CLERK BEVERLY KAUFMAN
TAX ASSESSOR LEO VASQUEZ

California Beaumont Zone of Ozone City



Canadian Ozone Association

Certificate of Completion

Awarded to

Tim Armsworthy

[illegible]

For successfully completing

CERTIFIED OZONE TRAINING

March 7th, 2010
Edmonton, Alberta

Michael Howard (Trainer)

Odor of ozone?

A. Like benzene
B. Like chlorine
C. Like fluorine
D. No odor

Ozone?

A. Like benzene
B. Like chlorine
C. Like fluorine
D. No odour

Smell? *ozein* (ὄζειν), the Greek verb for smell

Source of ozone layer

A. Xerox machines
B. Lightning + oxygen
C. UV radiation + oxygen
D. Airplanes
E. Forest fires

Ozone cycle

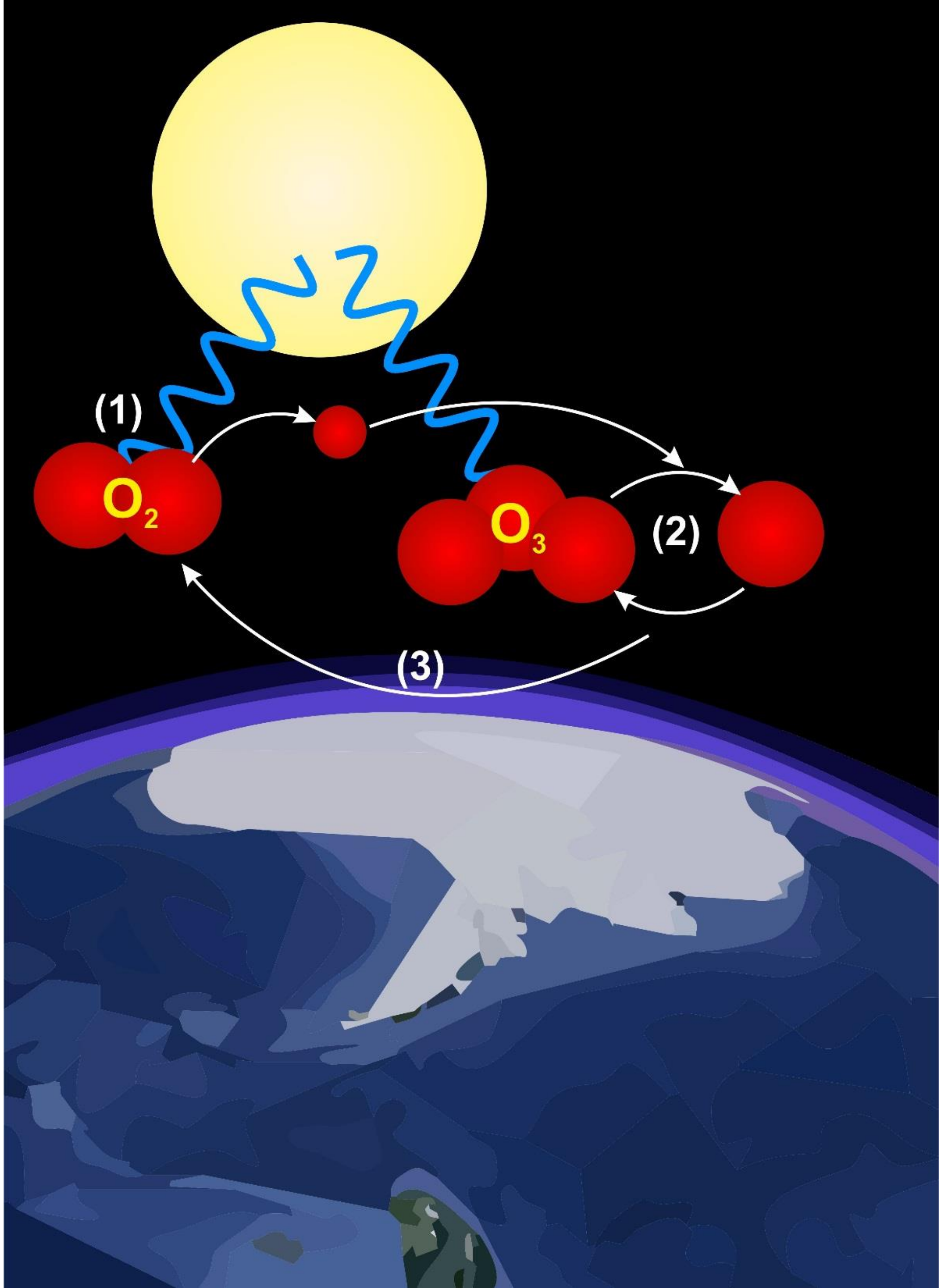
$$O_2 + h\nu \rightarrow 2O\cdot$$

UV-B
UV-C
100-315 nm
photolysis

radical=
unpaired
valence
electrons

$$O\cdot + O_2 \rightarrow O_3$$

- autocatalysis
- cycle



Source of ozone on Earth

A. Xerox machines
B. Lightning + oxygen
C. UV radiation + oxygen
D. Airplanes
E. Forest fires

How to find biospheres

- Galileo: find life on Earth
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- Near infrared spectrometer (NIMS)
- Large amount of O_3
  - Hard to explain abiologically
  - Also CH_4: this, together with O_3, important
  - Readily oxidized to give…

Methane + Oxygen = ?

A. Water
B. Carbon dioxide
C. All of the above

Methane + Oxygen = ?

A. Water
B. Carbon dioxide
C. All of the above

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Next time

- Planetary atmospheres
- Starshade

- Rothery et al. 262 – 280
- Longstaff: pp 366 – 375
- BS: 380 – 395