EPFL
PII Thermo

Clicker Questions; Session name: PhysIITD

Administration

Test Question:
To better understand Chemistry, good knowledge of Thermodynamics is...

A Useful

B Essential

C Not required

D Harmful

E I don't know

EPFL
PII Thermo

Clicker Question 1

Administration

In which language would you like this class to be taught?

A French

B English

C (Swiss)German

D Other

E Does not matter

Clicker Question 2

Boyles law...

A gives a relation between pressure, volume, and temperature of a gas

B is wrong

C gives a relation between pressure and volume of a gas

D is outdated

Notes

Answer:
C
Boyle measured volume as a function of pressure in a closed system at constant (ambient) temperature. He found that the two are inversely proportional, wich a constant that he did not further study.

Clicker Question 3

What is the volume of one mole of an ideal gas?

- A ca. 1 L
- B ca. 0.024 L
- C ca. 24 L
- D ca. 24 m^3
- E Question can't be answered
- F I don't know how to calculate this

Notes

Answer:
E
Temperature and pressure need to be specified to properly answer the question
Under standard conditions (1 bar, 300 K) the answer would be C

Clicker Question 4

Some History
Scientific Introduction
Mathematical Tools
Functions of Multiple Variables
Partial Derivatives

Given the function $f(x,y) = xy + x^2 + y^2$; What are the partial derivatives $\frac{\partial f}{\partial x}$ and $\frac{\partial f}{\partial y}$?

- A $\frac{\partial f}{\partial x} = 2x$
- B $\frac{\partial f}{\partial x} = y + x$
- C $\frac{\partial f}{\partial y} = x + x^2 + y$
- D $\frac{\partial f}{\partial y} = x + 2y$
- E I don't know

Notes

Introduction
1. Some History
1.1. Early Contributors
2. Scientific Introduction
3. Mathematical Tools
3.1. Functions of Multiple Variables
3.2. Partial Derivatives

Answer:
D
treat x like a constant and calculate the derivative w/respect to y as usual. (we here implicitly assume that x is constant for the partial derivative w/respect to y and vice-versa.
$\frac{\partial f}{\partial x} = y + 2x$

Clicker Question 5

Does $F(x, y) = x^2y^2 + y\sin(x)$ satisfy the theorem of Schwarz?

A Yes

B No

C I don't know what the theorem of Schwarz is

D I don't know how to find the answer to this question

Notes

Answer:
A
No calculation is necessary here. The theorem of Schwarz is satisfied for any function that is given as the function itself, rather than the differential. If we get $dF(x, y)$, we need to check; if we get $F(x, y)$, no check is required.

Clicker Question 6

Some History
Scientific Introduction
Mathematical Tools
Functions of Multiple Variables
Partial Derivatives

Given a differential $dF(x,y) = G(x,y)dx + H(x,y)dy$ **with** $G(x,y) = \sin(x)y^2$ **and** $H(x,y) = 3$.

Does $F(x,y)$ **satisfy the theorem of Schwarz?**

A Yes

B No

C I don't know what the theorem of Schwarz is

D I don't know how to find the answer to this question

Notes

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1. Some History
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B

$$\left(\frac{\partial G(x,y)}{\partial y}\right)_x = 2\sin(x)y \text{ and}$$
$$\left(\frac{\partial H(x,y)}{\partial x}\right)_y = 0$$

Since $\left(\frac{\partial G(x,y)}{\partial y}\right)_x \neq \left(\frac{\partial H(x,y)}{\partial x}\right)_y$, the theorem of Schwarz is not satisfied.

Clicker Question 7

Imagine a closed, hollow steel cylinder (1 m long, outer diameter 20 cm, wall thickness 5 mm). It is filled with water. Does it float in water?
($\rho(steel) = 8$ kg/L; $\rho(water) = 1000$ kg/m^3; $\rho(air) = 1200$ g/m^3)

A Yes

B No

C I don't know

Notes

Answer:
B
Approach to answer this question: Calculate the effective density of the cylinder, i.e. the total mass divided by the total volume.
Mass is given by the mass of the steel plus the water inside the cylinder. Since the density of steel is higher than that of water, the total effective density of the cylinder must be higher than that of pure water, hence the cylinder does not float.

Clicker Question 8

Imagine a closed, hollow steel cylinder (1 m long, outer diameter 20 cm, wall thickness 5 mm). It contains 6 litres of water, the rest is air. Does it float in water?
$(\rho(steel) = 8\ \mathrm{kg/L};\ \rho(water) = 1000\ \mathrm{kg/m^3};\ \rho(air) = 1200\ \mathrm{g/m^3})$

A Yes

B No

C I don't know

Notes

B
Approach to answer this question: Calculate the effective density of the cylinder, i.e. the total mass divided by the total volume.
Mass is given by the mass of the steel plus the water and the air inside the cylinder. Contrary to the previous question we here have to calculate the total mass explicitly:
Volume of a cylinder: $V_{cyl} = \pi r^2 h$, where r and h are radius and height, respectively.
outer cylinder: 0.031 $\mathrm{m^3}$=31 L;
inner cylinder: 0.028 $\mathrm{m^3}$ (note that for the inner cylinder both height and diameter are reduced by twice the wall thickness);
$m_{tot} = 3.3\ \mathrm{L} \cdot \rho_{steel} + 6\ \mathrm{L} \cdot \rho_{\mathrm{H_2O}} + 22\ \mathrm{L} \cdot \rho_{air}$=32.8 kg
$\rho_{total,eff}$=32.8 kg/0.031 $\mathrm{m^3}$=1044 $\mathrm{kg/m^3}$
since this is slightly higher than the density of water, the cylinder does not float.

Clicker Question 9

Why can I say that the density of the indicator does not depend on T?

A Because the temperature only affects the water, hence the indicators don't change

B Because the liquid in the indicator does not react to temperature.

C The density of the indicator does, in fact, change. But it does not affect our measurement.

D Because the indicator is enclosed in glass which barely reacts to temperature. Hence, the volume and thus the density of the indicators does not change.

E I don't know.

Notes

Scientific Introduction
1. TD systems
2. State Variables
3. State Functions
4. Ideal Gas Equation
4.1. Pressure
4.2. Rationalisation of pressure
4.3. Temperature

Answer:
D
The different indicators have similar volume, but their mass is different, corresponding to a different effective density (total mass relative to total volume).
We can assume the glass not to react to temperature, so even if the liquid inside it would change with temperature, the effective density remains the same.
So why does a change of temperature have any effect on the floating glass balls? Because the density of the fluid surrounding the glass balls (presumably water) changes density, and according to the buoyancy calculations we made, wether or not an object floats depends on the density difference between it, and its surrounding.s

Clicker Question 10

The speed of sound in air under ambient conditions is around 300 m/s. Compare this to the average speed of oxygen at 300 K. What do you conclude?

A The values are the same, thus I conclude that oxygen carries sound.

B The oxygen molecules move slower than sound, something is wrong.

C The oxygen molecules move faster than sound, something is wrong.

D The two quantities are not related.

E The relation is more complex than that.

F I dont understand the question.

Notes

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E

The oxygen molecules in air contribute to carrying sound, and sound waves are related to molecular motion. But the relation is not straightforward, hence we can not draw conclusions by comparing the speed of sound and the average speed of molecules.

Clicker Question 11

Which of the following statements is correct?

- A During an isothermal transformation p must change.
- B During an isochoric transformation V must change.
- C During an isothermal transformation in a closed system p follows a hyperbola in a p vs V plot.
- D During an isobaric transformation of an ideal gas pV=nRT does not hold.
- E I dont know.

Notes

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Answer:
C

- A Isothermal only specifies temperature. For a transformation at least one other variable must change, and hence (to keep $pV = nRT$ satisfied) another one as well. The two variables could be n and V, p does not have to change.
- B an isochoric transformation is defined as $\Delta V = 0$
- C $p = \frac{nRT}{V}$ which is a hyperbola in V. n=cst because the system is closed.
- D the ideal gas equation always holds within the approximations made here.

Clicker Question 12

In a 1D Maxwell-Boltzmann distribution for a given temperature the average velocity of O2 molecules in comparison with that of He atoms is:

A Higher

B Lower

C The same

D I don't know

Notes

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Answer:
B
O_2 is heavier than He. Because they have the same distribution of kinetic energy, heavier particles correspond to lower velocity.

Clicker Question 13

In a 3D Maxwell-Boltzmann distribution at 300 K the average kinetic energy of O2 molecules in comparison with He atoms is

A Higher

B Lower

C The same

D I don't know

Notes

First Law

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Answer:

C

The MB-distribution describes the probability of finding a specific kinetic energy, and it is the same for all particles.

Clicker Question 14

In the air that surrounds us (assuming only N_2 and O_2), all molecules...

A ... move at the same average speed

B ... move at the same speed

C ... have speed distributions defined by their mass

D ... have a speed distribution defined by the average mass of air molecules

E I don't know.

Notes

Answer:
C
The two gases have the same temperature but are otherwise independent.

First Law

1. Transformations

2. Internal Energy
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Clicker Question 15

Which of the following statements can be derived from the equipartition postulate by Boltzmann for ideal monoatomic gases?

A All particles have the same kinetic energy.

B All particles have the same velocity.

C The average velocity is the same for all particles in all directions.

D The average kinetic energy for all particles and all directions is the same.

E None of the above.

F I don't know.

Notes

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Answer:
D
See above - the MB distribution bases on the distribution of energy which, in the case of ideal monoatomic gases is only kinetic energy. All directions are equivalent, and the energy distribution is the same for all ideal gases.

Clicker Question 16

We have a tank (volume V) filled with helium at pressure p and temperature T. We now open the tank and remove half of the helium, such that $p_2 = p/2$. Assuming that T remains constant, which of the following statements is correct?

A The He atoms now move at half the speed
B The He atoms now move at twice the speed
C The speed distribution remains unchanged
D The new volume V_2 is $2V$
E I dont know

Notes

C
Speed distribution in an ideal gas is independent of density, and here the T is constant.

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Clicker Question 17

During the cycle on the previous slides we have compressions and expansions. For $V_B = 2V_A$, what are the relative internal energies at points A and B?

A $U_A > U_B$

B $U_A < U_B$

C $U_A = U_B$

D I dont know

Notes

C The internal energy of an ideal gas only depends on temperature. A and B are on the same isotherm.

First Law

1. Transformations

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Clicker Question 18

Trafo
Int. E
Work
Heat
Enthalpy
W / Q state fcts?
1st law
Cyclic transformations
Toward the second law

During the cycle on the previous slides we have compressions and expansions. What are the relative internal energies at points D and A?

A $U_A > U_D$

B $U_A < U_D$

C $U_A = U_D$

D I dont know

Notes

Answer:
A
The two points lie on different isotherms, the one for A corresponds to a higher T hence more internal energy.

First Law

1. Transformations

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9. Toward the second law

Clicker Question 19

What is the change of the internal energy during an isothermal compression?

A none, because the temperature remains constant

B positive because we perform work on the system

C negative because the volume is reduced

D I dont know

Notes

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Answer:
A
Isothermal compression of a closed system implies constant internal energy.
One could argue that it is not specified if the cylinder is open, hence n could change and we don't know what happens to the internal energy (answer D), but that is a bit of a stretch.

Clicker Question 20

Assume a tank equipped with a freely moving piston, filled with a quantity of Helium at certain p, T, V. We remove half of the Helium from the tank, but keep the temperature constant. What is the internal energy after this?

A The same, because the temperature remains constant

B Higher because by removing the helium, the piston moves inward, thus reducing the volume

C Lower because the amount of gas is lower

D I dont know

Notes

Answer:
C
Internal energy depends on T and on n. T remains constant here, but n is reduced, hence the internal energy is also reduced (fewer particles that carry kinetic energy).
B is wrong because even though the volume indeed is reduced, the internal energy is independent of volume.

First Law

1. Transformations

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9. Toward the second law

Clicker Question 21

How many degrees of freedom does a molecule of CO_2 have?

A 3

B 9

C 4

D 6

E I don't know.

Notes

Answer:
B
All degrees of freedom are counted, hence the answer is 3N with N=3.

First Law

1. Transformations

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Clicker Question 22

How many internal degrees of freedom does a molecule of CO_2 have?

- A 3
- B 9
- C 4
- D 6
- E I don't know.

Notes

First Law

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Answer:
D
Internal degrees of freedom are all those that are not translational, hence the answer is 3N-3=6

Clicker Question 23

How many vibrational modes does a molecule of CO_2 have?

A 3

B 9

C 4

D 6

E I don't know.

Notes

C
Linear molecule, hence 2 rotational degrees of freedom and 3N-5=4 vibrational degrees of freedom.

First Law

1. Transformations

2. Internal Energy
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Clicker Question 24

The observed heat capacity of molecules is larger than for atoms

A Always True

B Always False

C Sometimes True

D The question is ill-posed

E I dont know

Notes

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Answer:
C
At the lowest temperatures, the only degrees of freedom that contribute to the heat capacity are translational ones, and in that sense molecules behave like atoms. ”sometimes” means that at high temperatures molecules can have a larger heat capacity than atoms.

Clicker Question 25

To promote H_2 molecules from their ground state to the first vibrationally excited level, we need an energy of a bit over 4000 cm^{-1}, corresponding to ca. 47 kJ/mol. At what temperature does the vibrational degree of freedom start to contribute to the heat capacity?

A 47 K (the vibrational energy in Kelvin)

B Ca. 75 K (3/2 times the vibrational energy in Kelvin)

C 4000 K (the cm^{-1} value of the vibrational energy in Kelvin)

D 6000 K (the vibrational energy in units of Kelvin)

E They never contribute

F I have no idea how to answer this question.

Notes

Answer:
D
The other options make random unit conversions using numerical values that are the same. cm^{-1} and K can both be used as energy units. the former is related to light at a specific wavelength. Since the energy carried by the photons is inversely proportional to the wavelength, 1/length is related to energy as $E/hc = 1/\lambda$. This unit is often used in spectroscopy.
Kelvin can be used as an energy unit because temperature really is a measure of the amount of energy in a system (see Maxwell-Boltzmann distribution). The conversion of J to K is the Boltzmann constant k_B.
Comparing conversion factors shows that 1 cm^{-1} $\equiv$ 1.44 K and hence 4000 cm^{-1} $\approx$ 6000 K.

First Law

1. Transformations

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9. Toward the second law

Clicker Question 26

Which of the following statements are correct (multiple answers possible)?

A Q is a state function

B Q is not a state function, but for a cyclic transformation the total change in Q is always zero after a full cycle

C Q and W must compensate each other during a cyclic transformation (one full cycle)

D During a cyclic transformation U never changes

E The earth is flat

F All wrong

G I don't know

Notes

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Answer:
C
Q is not a state function, and the total Q can be non-zero during a cyclic transformation. However U is a state function and since Q and W both represent energy exchanges, they must sum to zero to satisfy $\Delta U_{cycl} = W + Q = 0$ for a complete cycle.
E is debatable.

Clicker Question 27

Trafo
Int. E
Work
Heat
Enthalpy
W / Q state fcts?
W
Q
1st law
Cyclic transformations
Toward the second law

The heat capacity of a gas in general increases with increasing temperature because...

- A at higher temperature the molecules move faster
- B at higher temperature the change in energy per unit temperature becomes smaller
- C the number of degrees of freedom in a gas increases with increasing temperature
- D it actually does not increase
- E new forms of microscopic energy storage become available with increasing temperature
- F the earth is flat
- G None of the above
- H I dont know

Notes

Answer:
E
This is equivalent to the statement that some degrees of freedom only become active above a certain temperature.
F remains debatable

First Law

1. Transformations

2. Internal Energy
2.1. Kinetic Theory of Gases
2.2. Changing the internal energy

3. Work

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Clicker Question 28

During an isochoric transformation of an ideal gas:

- A $\Delta V = 0; W = 0$
- B $\Delta p = 0; W = 0$
- C W is a state function
- D $\Delta V = 0;\ \Delta U = 0$
- E None of the above
- F I don't know.

Notes

Answer:
A (definition of work)

First Law

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Clicker Question 29

During an isothermal transformation of an ideal gas:

- A $Q = 0$
- B $\Delta U = W$
- C $W = nRT(V_f - V_i)$
- D $W = -nRT \ln\left(\frac{V_f}{V_i}\right)$
- E None of the above.
- F I don't know

Notes

Answer:
D
Calculating $\int_{V_i}^{V_f} -pdV = \int_{V_i}^{V_f} -\frac{nRT}{V} dV$ yields this expression.
A and B would be correct for an adiabatic transformation
Note the implicit assumption that we are looking at a closed system.

First Law

1. Transformations

2. Internal Energy
2.1. Kinetic Theory of Gases
2.2. Changing the internal energy

3. Work

4. Heat
4.1. Degrees of Freedom
4.2. Heat Capacity

5. Enthalpy

6. Are W and Q state functions?
6.1. Is W a state function?
6.2. Is Q a state function?

7. The First Law of TD
7.1. Conservative vs. non-conservative forces
7.2. Types of Transformations
7.3. Work during a quasi-static transformation

8. Cyclic transformations

9. Toward the second law

Clicker Question 30

Trafo
Int. E
Work
Heat
Enthalpy
W / Q state fcts?
1st law
  Cons / non-cons F
  Types of Trafo
  W during trafo
Cyclic transformations
Toward the second law

During an isobaric transformation of an ideal gas:

- A $Q = 0$
- B $\Delta U = W$
- C $W = nRT(V_f - V_i)$
- D $pV = nRT$
- E None of the above.
- F I don't know

Notes

First Law
1. Transformations
2. Internal Energy
2.1. Kinetic Theory of Gases
2.2. Changing the internal energy
3. Work
4. Heat
4.1. Degrees of Freedom
4.2. Heat Capacity
5. Enthalpy
6. Are W and Q state functions?
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7. The First Law of TD
7.1. Conservative vs. non-conservative forces
7.2. Types of Transformations
7.3. Work during a quasi-static transformation
8. Cyclic transformations
9. Toward the second law

Answer:
D
The ideal gas equation always holds (for an ideal gas)

Clicker Question 31

Which of the following statements is correct?

- A The first principle states that the internal energy of any system is conserved
- B $Q = -W$ (always)
- C The first principle of Thermodynamics only applies to ideal gases
- D The internal energy does not change during an isothermal transformation
- E All of the above
- F None of the above
- G I don't know

Notes

First Law

1. Transformations
2. Internal Energy
2.1. Kinetic Theory of Gases
2.2. Changing the internal energy
3. Work
4. Heat
4.1. Degrees of Freedom
4.2. Heat Capacity
5. Enthalpy
6. Are W and Q state functions?
6.1. Is W a state function?
6.2. Is Q a state function?
7. The First Law of TD
7.1. Conservative vs. non-conservative forces
7.2. Types of Transformations
7.3. Work during a quasi-static transformation
8. Cyclic transformations
9. Toward the second law

Answer:
strictly speaking, it is F, for the following reasons:

- A is wrong because the system can exchange energy with its environment. The first principle states that the total energy is conserved, not specifically that of a system.
- B is correct only if the internal energy of a system is constant
- C The first principle is a general principle of thermodynamics and also applies to real gases, as well as to solids and liquids.
- D is almost correct, but it would also have to be specified that the quantity of gas remains constant. Isothermal only defines that the temperature is constant. if n and T are constant, then indeed the internal energy is constant as well.

Clicker Question 32

Based on what we have discussed so far in this course, perpetual motion is. . .

A Impossible because it would violate the first principle
B Impossible because U is a state function
C Possible because it does not violate the first principle
D Possible despite violating the first principle
E Impossible because the earth is flat
F I dont know

Notes

Answer:
C
The first principle defines conservation of energy, perpetual motion does not violate that principle. It does violate what we will introduce as the second principle of thermodynamics, which defines the concept of entropy.

First Law

1. Transformations

2. Internal Energy
2.1. Kinetic Theory of Gases
2.2. Changing the internal energy

3. Work

4. Heat
4.1. Degrees of Freedom
4.2. Heat Capacity

5. Enthalpy

6. Are W and Q state functions?
6.1. Is W a state function?
6.2. Is Q a state function?

7. The First Law of TD
7.1. Conservative vs. non-conservative forces
7.2. Types of Transformations
7.3. Work during a quasi-static transformation

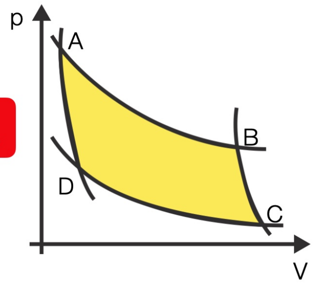
8. Cyclic transformations

9. Toward the second law

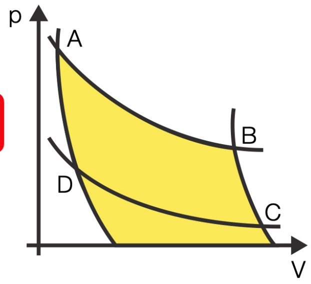
Clicker Question 33

During a cyclic transformation A-B-C-D-A, work performed during step A-B corresponds to the following area (see diagrams on slide):

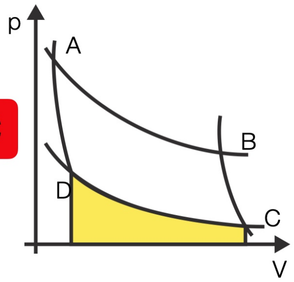
A



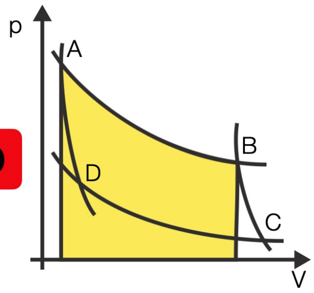
B



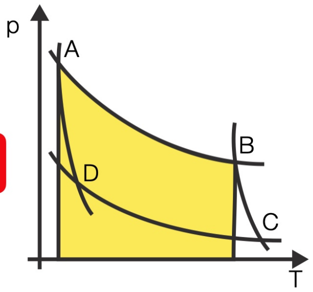
C



D



E



F None of these

G I dont know

Notes

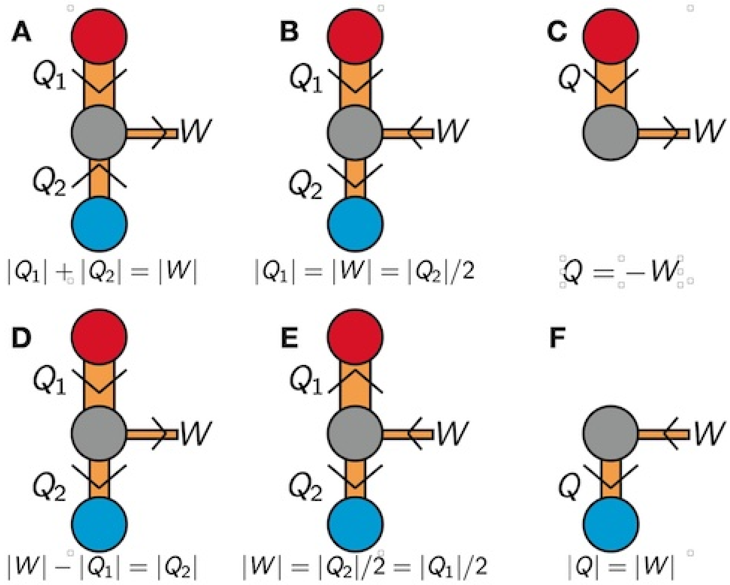
Second Law
1. TD Cycles
2. Carnot Cycle
2.1. Alternative modes of operation
3. Stirling Cycle
4. Other Cycles
5. Second Law
5.1. Toward Entropy
5.2. Entropy: general observations
5.3. Entropy
5.4. Carnot Cycle and Entropy
5.5. Rewriting U
6. Auxiliary Functions
6.1. Maxwell Relations
7. Eq. of state

Answer:
D

- A is the total work for the cycle,
- B is no physical quantity
- C is work for the step C-D
- E is a p-T diagram, hence the yellow area has no physical meaning.

Clicker Question 34

Considering only the first law of Thermodynamics, which of the engines on the slide is/are possible (Multiple answers possible)?



Considering only the first law of Thermodynamics, which of those is possible?
(Multiple answers possible)

A-F (respectively)
G all of them
H none of them
I I don't know

Notes

Second Law
1. TD Cycles
2. Carnot Cycle
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5. Second Law
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5.2. Entropy: general observations
5.3. Entropy
5.4. Carnot Cycle and Entropy
5.5. Rewriting U
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6.1. Maxwell Relations
7. Eq. of state

Answer:
The first law states the conservation of energy, hence it is irrelevant if a process is possible from the perspective of entropy (second law). To answer this question, we simply calculate the energy balance and ensure that the energy-flow into the system is compensated by the flow out of the system (direction indicated by the arrows).
For example: A is possible because the sum of the inflow ($Q_1 + Q_2$) is the same as the outflow (W), hence it is permitted according to the first law. It is, however, not possible to construct an engine like this, because it would violate the second law.
By this reasoning one can find that all engines except D are possible. Indeed in D the inflow is $|Q_1|$ and the outflow is $|W| + |Q_2|$. Yet the condition states that $|W| - |Q_2| = |Q_1|$.

Clicker Question 35

It is a hot summer day and you are sweating in your kitchen. Your favorite influencer calls you on the phone and suggests that you open the fridge to cool down the kitchen. Which of the following is/are appropriate? (Multiple answers possible)

A What is a phone call?

B I agree with him and open the fridge to cool down the room. (justification)

C She actually knows about thermodynamics and would thus never suggest something like this. (justification).

D Opening the fridge would not change the temperature of the room (justification).

E I dont have a kitchen.

F I dont know.

Notes

Second Law
1. TD Cycles
2. Carnot Cycle
2.1. Alternative modes of operation
3. Stirling Cycle
4. Other Cycles
5. Second Law
5.1. Toward Entropy
5.2. Entropy: general observations
5.3. Entropy
5.4. Carnot Cycle and Entropy
5.5. Rewriting U
6. Auxiliary Functions
6.1. Maxwell Relations
7. Eq. of state

Answer:
C
Operating a fridge heats more on the output side than it cools on the input, hence operating a fridge with an open door effectively heats the room.

Clicker Question 36

A car is operated with a Carnot engine with $T_H = 800^\circ C$ and $T_L = 70^\circ C$. It uses gasoline (energy content of 35 MJ/L) to produce the energy for the hot reservoir. How many litres of gasoline are required to drive a 1T car from Lausanne (350 meters above sea level) up to the Simplon pass (2000 meters above sea level), 170 km away, at an average speed of 80 km/h? (Neglecting the initial acceleration as well as friction and air drag.)
How many litres of gasoline are required (rounded to the nearest integer number)?

- A 10
- B 5
- C 0 (justify)
- D It can not be done
- E I don't know

Notes

Answer:
Calculation: we use the two temperatures to calculate the efficiency of the engine, then we calculate the energy that is required to move the car. Because the efficiency is lower than 1, we actually must "pay" more energy than the bare requirement (we divide by the efficiency). This amount of energy is converted to volume of gasoline by considering the energy content of gasoline. Note that because we neglect friction and airdrag, the speed of the car is irrelevant, the only thing we need to take into account is the change of potential energy.
We find a gain in E_{pot} of about 16 MJ and an efficiency of $\eta = 0.68$, hence 24 MJ of required energy. This corresponds to less that one litre, so the correct answer is C.

Clicker Question 37

TD Cycles
Carnot Cycle
Alternative modes of operation
Stirling Cycle
Other Cycles
Second Law
Auxiliary Functions
Eq. of state

We now drive the same car around the lake of Geneva. (Still neglecting the initial acceleration, friction and air drag.)
How many litres of gasoline are required (rounded to the nearest integer number)?

- A 2
- B 1
- C 0 (justify)
- D It can not be done
- E I don't know

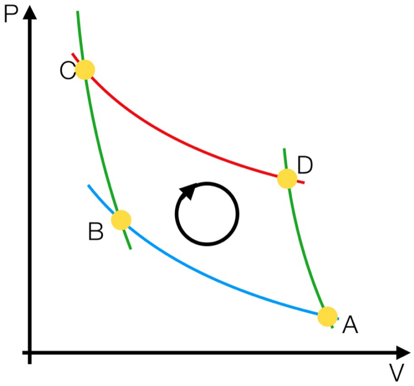
Notes

Second Law
1. TD Cycles
2. Carnot Cycle
2.1. Alternative modes of operation
3. Stirling Cycle
4. Other Cycles
5. Second Law
5.1. Toward Entropy
5.2. Entropy: general observations
5.3. Entropy
5.4. Carnot Cycle and Entropy
5.5. Rewriting U
6. Auxiliary Functions
6.1. Maxwell Relations
7. Eq. of state

Answer:
Strictly speaking, D is correct because we neglect friction and can hence not take the necessary turns to drive around the lake.
Neglecting this would mean that we can drive with zero energy use because there is no altitude difference, and we still neglect friction and airdrag.

Clicker Question 38

Which of the following measure(s) would lead to a reduction of that amount, still assuming the engine is described by a Carnot cycle (multiple answers possible)?



A) Higher compression ratio (increase V_A/V_B)
B) Run overall at higher pressures (increase all P_i)
C) Increase T_H while keeping T_C the same
D) Make the car smaller and more aerodynamic
E) All of the above
F) None of the above
G) I don't know

Notes

Second Law
1. TD Cycles
2. Carnot Cycle
2.1. Alternative modes of operation
3. Stirling Cycle
4. Other Cycles
5. Second Law
5.1. Toward Entropy
5.2. Entropy: general observations
5.3. Entropy
5.4. Carnot Cycle and Entropy
5.5. Rewriting U
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6.1. Maxwell Relations
7. Eq. of state

Answer:
We want to operate the engine at a higher efficiency. In a Carnot cycle we can change the efficiency by changing the temperatures, C is correct.
D has no effect because we neglect friction and airdrag. Smaller is not the same as lighter.

Clicker Question 39

By cleaning my room I reduce disorder and thus overall reduce entropy.

- A Correct
- B I reduce disorder in my room, but I don't reduce the overall entropy
- C By cleaning I increase entropy in my room
- D I never clean my room
- E My room is completely empty, so there is no entropy
- F I don't know

Notes

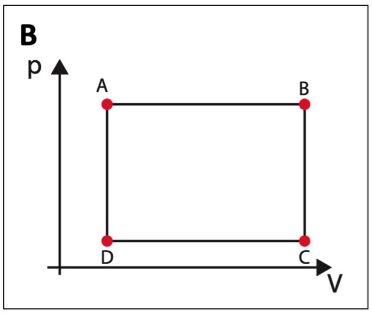
Second Law
1. TD Cycles
2. Carnot Cycle
2.1. Alternative modes of operation
3. Stirling Cycle
4. Other Cycles
5. Second Law
5.1. Toward Entropy
5.2. Entropy: general observations
5.3. Entropy
5.4. Carnot Cycle and Entropy
5.5. Rewriting U
6. Auxiliary Functions
6.1. Maxwell Relations
7. Eq. of state

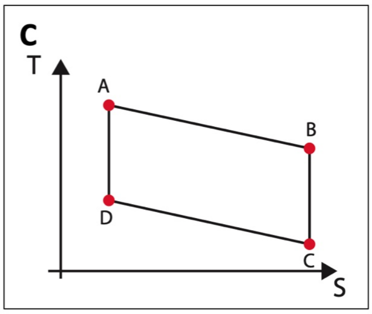
Answer:
B
By cleaning I reduce the entropy of the room, but since I (as the person doing the cleaning) must be included, the overall entropy increases.

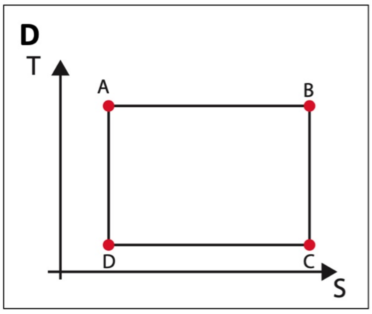
Clicker Question 40

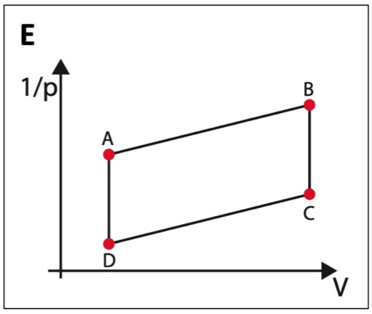
Which of the following diagram(s) correctly represent(s) a Stirling cycle? (Multiple answers possible)

A I don't know









F None of the above

Notes

Answer:
D; see slides

Second Law

1. TD Cycles
2. Carnot Cycle
2.1. Alternative modes of operation
3. Stirling Cycle
4. Other Cycles
5. Second Law
5.1. Toward Entropy
5.2. Entropy: general observations
5.3. Entropy
5.4. Carnot Cycle and Entropy
5.5. Rewriting U
6. Auxiliary Functions
6.1. Maxwell Relations
7. Eq. of state

Clicker Question 41

Q=TdS

- A Always correct
- B Never correct
- C Sometimes correct
- D I don't know

Notes

Second Law

1. TD Cycles
2. Carnot Cycle
2.1. Alternative modes of operation
3. Stirling Cycle
4. Other Cycles
5. Second Law
5.1. Toward Entropy
5.2. Entropy: general observations
5.3. Entropy
5.4. Carnot Cycle and Entropy
5.5. Rewriting U
6. Auxiliary Functions
6.1. Maxwell Relations
7. Eq. of state

Answer:
C
It is correct in the case of a reversible transformation.

Clicker Question 42

During an adiabatic transformation, the entropy of the system

A remains constant

B decreases

C increases

D can change

E I don't know

Notes

Second Law

1. TD Cycles
2. Carnot Cycle
2.1. Alternative modes of operation
3. Stirling Cycle
4. Other Cycles
5. Second Law
5.1. Toward Entropy
5.2. Entropy: general observations
5.3. Entropy
5.4. Carnot Cycle and Entropy
5.5. Rewriting U
6. Auxiliary Functions
6.1. Maxwell Relations
7. Eq. of state

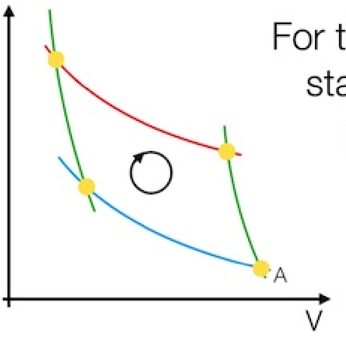
Answer:

D

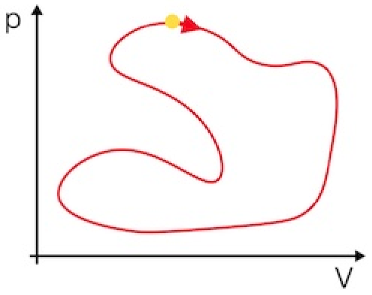
In case of an irreversible transformation. For reversible adiabatic transformations, A is correct. Such transformations are called "isentropic".

Clicker Question 43

A



B



For the cyclic transformations shown here, which statement about the total entropy change for paths A (Carnot cycle) and B is correct?

A. $\Delta S(A) = \Delta S(B)$
B. $\Delta S(A) > \Delta S(B)$
C. $\Delta S(A) < \Delta S(B)$
D. I don't know

Notes

Real Gases
1. Joule-Thomson Effect
2. Real gases
2.1. Interaction Potentials
2.2. State equation for non-ideal gases
3. Phase Transitions
3.1. Change of TD functions

Answer:
One may assume that C is correct, based on the cycles we have seen.
However since we dont know the details of the cycles and the different transformations, strictly speaking we dont know, so D would be correct.

Clicker Question 44

Would you expect there to be a correlation between the values of the VdW coefficients and the boiling point of a given species?

- A Yes (justify)
- B No (justify)
- C I dont know

Notes

Real Gases
1. Joule-Thomson Effect
2. Real gases
2.1. Interaction Potentials
2.2. State equation for non-ideal gases
3. Phase Transitions
3.1. Change of TD functions

Answer:
A
The VdW coefficients describe the interactions between particles, and these are also what defines the boiling temperature of a liquid (more energy is required if the interactions are stronger, hence the boiling point is higher).

Clicker Question 45

Water boils at 100 °C. Assume water would behave like an ideal gas, what could you say about the boiling temperature?

A It remains at 100 °C

B Depends on the pressure

C It is higher

D It is lower

E No boiling point, this water would always be a liquid

F No boiling point, this water would always be a gas

G I don't know

Notes

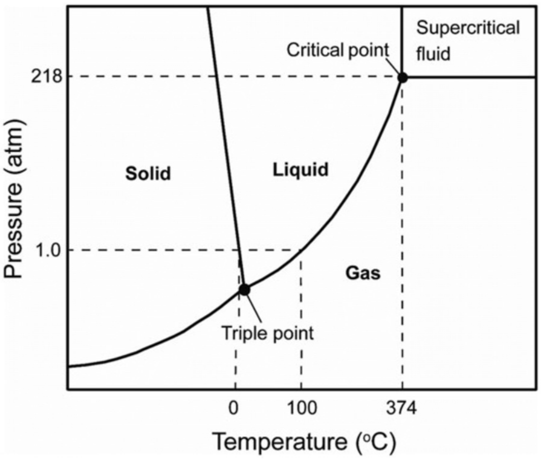
Real Gases
1. Joule-Thomson Effect
2. Real gases
2.1. Interaction Potentials
2.2. State equation for non-ideal gases
3. Phase Transitions
3.1. Change of TD functions

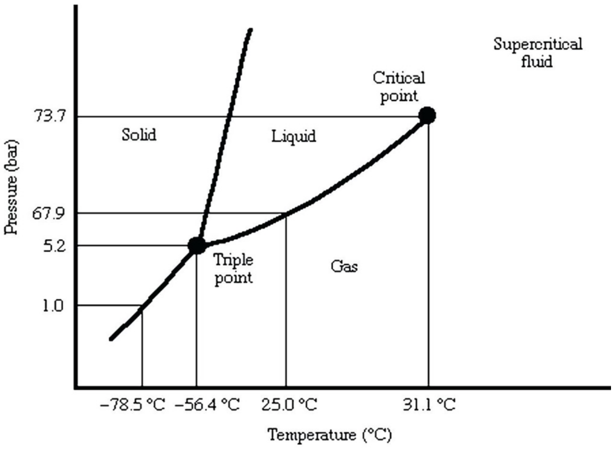
Answer:
F
Ideal gases are defined as non-interacting particles, yet condensation requires interactions. An ideal gas is always a gas.

Clicker Question 46

Of the two phase diagrams shown below, one is for water while the other is for CO_2. Which is which?

A Left water, right CO_2
B Left CO_2 right water
C Impossible to tell
D Neither is for either of these
E I don't know





Notes

Real Gases
1. Joule-Thomson Effect
2. Real gases
2.1. Interaction Potentials
2.2. State equation for non-ideal gases
3. Phase Transitions
3.1. Change of TD functions

Answer:

A

We know that the melting point of water is at 0 °C, the boiling point is 100 °C (both for 1 bar).

Clicker Question 47

What happens to solid water at -1 °C when I increase the pressure from 1 bar to 100 bars?

A Nothing (remains solid)
B It becomes liquid
C It turns into a gas
D It explodes
E I dont know

Notes

Answer:
B
Increasing the pressure at constant temperature corresponds to a transformation along a vertical line. If we follow a vertical line at 1 °C we see that at a pressure of around 100 atm we make a phase transition from solid to liquid.
This effect is the basis of ice-skating where a liquid film of water is formed under the skates, hence reducing friction and making possible the gliding.

Clicker Question 48

Part. Mol. Quantities
Chem. Pot.
Mixing S
Mix.real gases
Collig.eff
Melting point
Boiling point
Change of Phase Transitions
Osmotic Pressure
Gas-Liq equil for mixt.
Distillation
Mix.real sol.
Liq-Vap Equil
Solubility

Sugar can also be used to de-ice roads in the winter, just like salt.

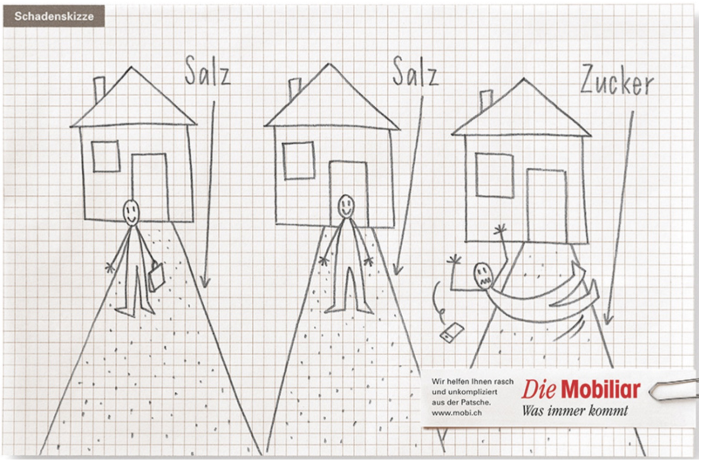
A True

B False

C True, but it requires twice the mass

D True, but it requires twice the amount (in moles)

E I dont know



Notes

Mixtures
1. Partial Molar Quantities
2. Chemical Potential
2.1. Standard Conditions
3. Mixing entropy
4. Mixtures of real gases
5. Colligative effects
5.1. Melting point
5.2. Boiling point
5.3. Change of Phase Transitions
5.4. Osmotic Pressure
6. Gas-Liquid equilibrium for Mixtures
7. Distillation
8. Mixtures of real solutions
9. Liquid-vapor equilibrium of real mixtures
10. Solubility

Answer:

D

The melting point reduction is related to the mole fractions, which is why it includes the amount of added solute and the van't Hoff number which is the number of particles formed per particle added. One mole of salt dissociates into 1 mole of Na^+ and 1 mole of Cl^-, corresponding to a total of 2 moles of added particles (i=2). In the case of sugar there is no dissociation, hence 1 mole of sugar is equivalent to 1 mole of added particles (i=1). To achieve the same mole fraction of water, we must add twice the amount of sugar (in moles).

Clicker Question 49

Part. Mol. Quantities
Chem. Pot.
Mixing S
Mix.real gases
Collig.eff
Melting point
Boiling point
Change of Phase Transitions
Osmotic Pressure
Gas-Liq equil for mixt.
Distillation
Mix.real sol.
Liq-Vap Equil
Solubility

Dissolving sugar in water leads to a solution with the same osmotic pressure as dissolving salt (NaCl) in water.

- A Always true
- B Never true
- C Can be true, but it requires more NaCl (in moles)
- D Can be true, but it requires more Sugar (in moles)
- E Can be true, but the amounts must be same (in moles)
- F All wrong
- G I dont know

Notes

Answer:
D - see above

Mixtures

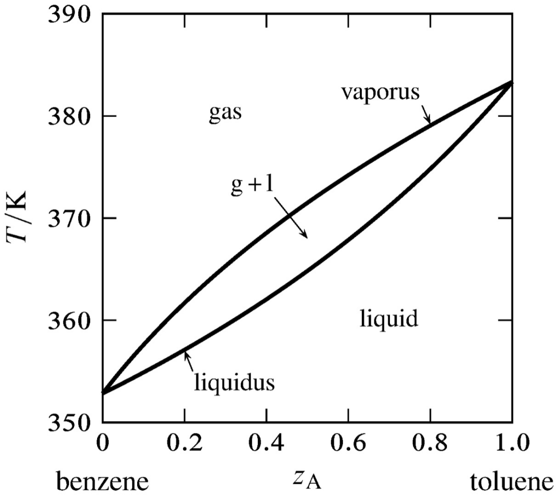
1. Partial Molar Quantities
2. Chemical Potential
2.1. Standard Conditions
3. Mixing entropy
4. Mixtures of real gases
5. Colligative effects
5.1. Melting point
5.2. Boiling point
5.3. Change of Phase Transitions
5.4. Osmotic Pressure
6. Gas-Liquid equilibrium for Mixtures
7. Distillation
8. Mixtures of real solutions
9. Liquid-vapor equilibrium of real mixtures
10. Solubility

Clicker Question 50

Part. Mol. Quantities
Chem. Pot.
Mixing S
Mix.real gases
Collig.eff
Gas-Liq equil for mixt.
Distillation
Mix.real sol.
Liq-Vap Equil
Solubility

Assume a 1:1 solution of benzene and toluene. If we perform a simple (one-step) distillation of it, what is the mole fraction of toluene in the collector?

- A 0
- B 0.3
- C 0.5
- D 0.7
- E 1
- F I dont know



Notes

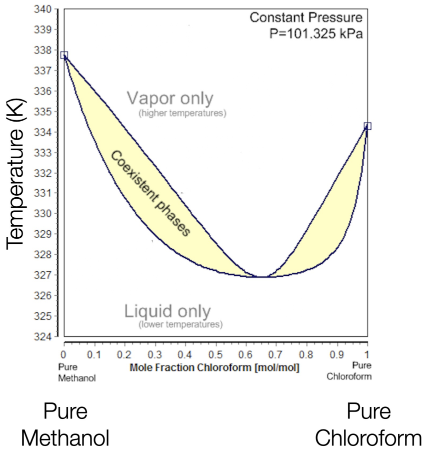
Mixtures
1. Partial Molar Quantities
2. Chemical Potential
2.1. Standard Conditions
3. Mixing entropy
4. Mixtures of real gases
5. Colligative effects
5.1. Melting point
5.2. Boiling point
5.3. Change of Phase Transitions
5.4. Osmotic Pressure
6. Gas-Liquid equilibrium for Mixtures
7. Distillation
8. Mixtures of real solutions
9. Liquid-vapor equilibrium of real mixtures
10. Solubility

Answer:
B

Clicker Question 51

Assume the phase diagram on the left, for a Methanol/Chloroform mixture. For an initial mole fraction of 0.2 Chloroform, what is the final mole fraction of Chloroform after fractional distillation?

A 0
B 0.2 (Bc. Azeotrope)
C 1
D 0.65
E 0.35
F I dont know



Notes

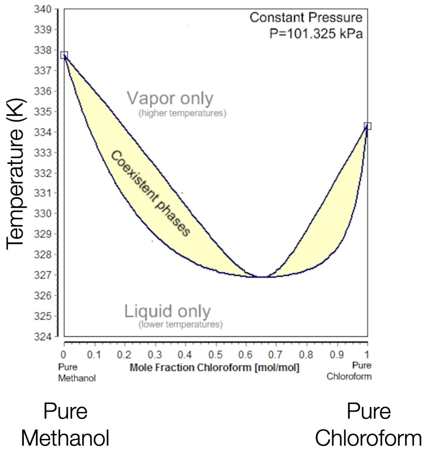
Mixtures
1. Partial Molar Quantities
2. Chemical Potential
2.1. Standard Conditions
3. Mixing entropy
4. Mixtures of real gases
5. Colligative effects
5.1. Melting point
5.2. Boiling point
5.3. Change of Phase Transitions
5.4. Osmotic Pressure
6. Gas-Liquid equilibrium for Mixtures
7. Distillation
8. Mixtures of real solutions
9. Liquid-vapor equilibrium of real mixtures
10. Solubility

Answer:
D
The solution in the collector is the one with the lowest boiling point, hence the azeotrope. Here, the mole fraction of Chloroform is 0.65.

Clicker Question 52

Assume the phase diagram on the left, for a Methanol/Chloroform mixture. For an initial mole fraction of 0.9 Chloroform, what is the final mole fraction of Chloroform after fractional distillation?

- A 0
- B 0.9 (Bc. Azeotrope)
- C 1
- D 0.65
- E 0.35
- F I dont know



Notes

Answer:

D

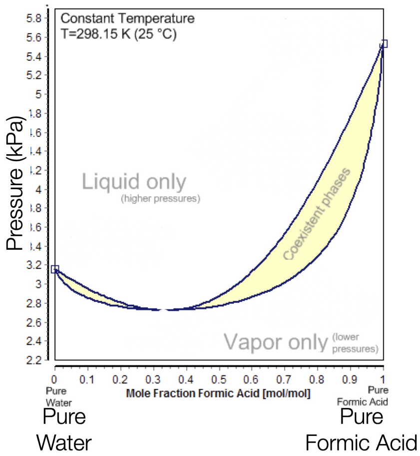
Same as in the previous question: the solution in the collector is the one with the lowest boiling point, hence the azeotrope. Here, the mole fraction of Chloroform is 0.65.

Mixtures
1. Partial Molar Quantities
2. Chemical Potential
2.1. Standard Conditions
3. Mixing entropy
4. Mixtures of real gases
5. Colligative effects
5.1. Melting point
5.2. Boiling point
5.3. Change of Phase Transitions
5.4. Osmotic Pressure
6. Gas-Liquid equilibrium for Mixtures
7. Distillation
8. Mixtures of real solutions
9. Liquid-vapor equilibrium of real mixtures
10. Solubility

Clicker Question 53

Assume the phase diagram below, for a Water/Formic Acid mixture. For an initial mole fraction of 0.9 Water, what is the final mole fraction of Water after fractional distillation?

- A 0
- B 0.9 (Bc. Azeotrope)
- C 1
- D 0.32
- E 0.68
- F I dont know



Notes

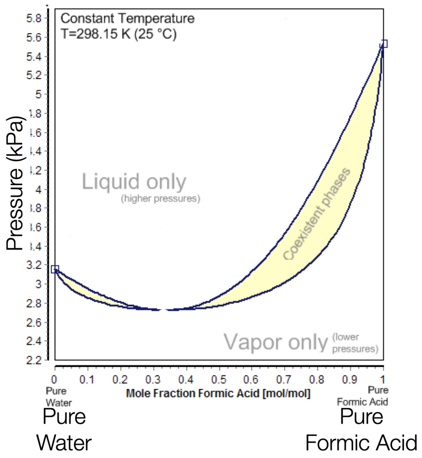
Mixtures
1. Partial Molar Quantities
2. Chemical Potential
2.1. Standard Conditions
3. Mixing entropy
4. Mixtures of real gases
5. Colligative effects
5.1. Melting point
5.2. Boiling point
5.3. Change of Phase Transitions
5.4. Osmotic Pressure
6. Gas-Liquid equilibrium for Mixtures
7. Distillation
8. Mixtures of real solutions
9. Liquid-vapor equilibrium of real mixtures
10. Solubility

This diagram shows pressure as a function of mole fraction. Hence, if we perform a regular distillation (by heating), we must think of the phase diagram as inverted, and we find a maximum boiling temperature for the azeotrope. The solution in the collector will be the one with the lowest boiling temperature or, in the current representation, the highest vapor pressure.
Applying these arguments yields C as the correct answer.
Note that we never cross through the azeotrope because at that point the composition of the vapor is the same as that of the solution, hence the distillation stops.

Clicker Question 54

Assume the phase diagram below, for a Water/Formic Acid mixture. For an initial mole fraction of 0.2 Water, what is the final mole fraction of Water after fractional distillation?

- A 0
- B 0.2 (Bc. Azeotrope)
- C 1
- D 0.32
- E 0.68
- F I dont know



Notes

Mixtures
1. Partial Molar Quantities
2. Chemical Potential
2.1. Standard Conditions
3. Mixing entropy
4. Mixtures of real gases
5. Colligative effects
5.1. Melting point
5.2. Boiling point
5.3. Change of Phase Transitions
5.4. Osmotic Pressure
6. Gas-Liquid equilibrium for Mixtures
7. Distillation
8. Mixtures of real solutions
9. Liquid-vapor equilibrium of real mixtures
10. Solubility

Answer:

A

The mole fraction of water in the collector will be zero, that in the original container will be 0.68.

Clicker Question 55

When I open a bottle of Champaign, the cork flies off.

- A This is because of Henry’s law
- B This is because of Raoult’s law
- C This because of the conical shape of the kork
- D This is because the bottle was pressurised
- E The cork does not fly off because I use a sword
- F None of the above
- G All of the above
- H I don’t know

Notes

Answer:
D
Henrys law describes the change of solubility as a function of pressure, but does not create a pressure and hence is not what makes the cork fly off.
Experienced users tell me that E is also correct.

Mixtures

1. Partial Molar Quantities

2. Chemical Potential
2.1. Standard Conditions

3. Mixing entropy

4. Mixtures of real gases

5. Colligative effects
5.1. Melting point
5.2. Boiling point
5.3. Change of Phase Transitions
5.4. Osmotic Pressure

6. Gas-Liquid equilibrium for Mixtures

7. Distillation

8. Mixtures of real solutions

9. Liquid-vapor equilibrium of real mixtures

10. Solubility

Clicker Question 56

When I open a bottle of Champaign, bubbles form.

A This is because of Henry's law
B This is because of Raoult's law
C This because of the conical shape of the cork
D This is because the bottle was pressurised
E None of the above
F Multiple correct answers
G I dont know

Notes

Mixtures
1. Partial Molar Quantities
2. Chemical Potential
2.1. Standard Conditions
3. Mixing entropy
4. Mixtures of real gases
5. Colligative effects
5.1. Melting point
5.2. Boiling point
5.3. Change of Phase Transitions
5.4. Osmotic Pressure
6. Gas-Liquid equilibrium for Mixtures
7. Distillation
8. Mixtures of real solutions
9. Liquid-vapor equilibrium of real mixtures
10. Solubility

Answer:
A
If the external pressure reduces, the solubility for the CO_2 is reduced (the vapor pressure is higher than the external pressure), hence bubbles form.