

Identify the process and constraints

Page 1 | A and B | Pause at slides 4 (8 min) and 8 (6 min). Keep attempts and corrections separately.

Start at [week04-study.html](#). This independent lesson replaces class while the instructor attends the ECS meeting. Use the video OR the same slides, this worksheet, a calculator and the four-page Lab guide. Plan approximately three hours. The video page reports measured recording time plus 120 minutes of work and a 10-minute break. No additional compulsory preparation or follow-up is assigned.

A. What process are you describing?

A1. Classify: (i) a pure solid dissolves into a liquid mixture, (ii) volatile solid enters the gas phase in a sealed vessel, (iii) gas molecules accumulate on an adsorbent surface. Name SLE, bulk GSE or adsorption, and identify the phases involved.

A2. Week 3 compared liquid states at fixed T and P. Which equilibrium potential is appropriate for a closed, rigid vessel at fixed T and free gas volume? State the conserved amount and explain why pressure is now an output.

A3. Predict whether adding inert gas at fixed T and V changes the volatile partial pressure while solid remains. Does the same answer apply to total pressure? State the ideal-gas assumption.

B. One pure-solid solubility calculation

For a present pure solid i, use $\ln(x_i\gamma_i) = -(\Delta H_{\text{fus},i}/R)(1/T - 1/T_{\text{m},i})$. Set $R = 8.314462618 \text{ J mol}^{-1} \text{ K}^{-1}$, $T_{\text{m}} = 350 \text{ K}$, $\Delta H_{\text{fus}} = 10000 \text{ J/mol}$ and $T = 300 \text{ K}$. Assume constant fusion enthalpy, negligible fusion heat-capacity correction and ideal liquid ($\gamma_i = 1$).

B1. Substitute the values, calculate $\ln x_i$ and then x_i . Keep the sign and units explicit.

B2. Is x_i a phase fraction or a composition in the saturated liquid? Can it determine how many moles of solid remain without an inventory balance? Explain what changes when γ_i is not 1.

This is one liquidus relation below the pure-component melting point, not a complete binary phase diagram. Pure-solid activity is 1 only for a present pure solid on its own standard state; its liquid-reference activity need not be 1.

Check a finite gas-solid inventory

Page 2 | C1-C3 | Slide 13: 10-minute independent attempt before the numerical check.

C. New volume and sublimation pressure

A synthetic volatile solid and an ideal gas share a closed vessel at $T=300\text{ K}$, free gas volume $V=2.00\text{ L}$ and sublimation pressure $P_{\text{sub}}=8.00\text{ kPa}$. Compare volatile inventories $n_A=0.0100\text{ mol}$ and 0.00400 mol . Initially there is no inert gas. Use $R=8.314462618\text{ kPa L mol}^{-1}\text{ K}^{-1}$.

$$n_{\text{cap}} = P_{\text{sub}} V / (RT); n_{\text{gas}} = \min(n_A, n_{\text{cap}}); n_{\text{solid}} = n_A - n_{\text{gas}}; P_A = n_{\text{gas}} RT / V.$$

C1. Calculate n_{cap} . Complete the table and check $n_A = n_{\text{gas}} + n_{\text{solid}}$ for both inventories. Explain why $P_A = P_{\text{sub}}$ is conditional on a solid phase remaining.

n_A / mol	$n_{\text{gas}} / \text{mol}$	$n_{\text{solid}} / \text{mol}$	P_A / kPa	Present phases
0.0100				
0.00400				

C2. Add $n_{\text{inert}}=0.00100\text{ mol}$ at the same T and free volume to each case. Calculate P_{inert} and P_{total} . Do n_{gas} , n_{solid} or P_A change? Do not replace P_A by P_{total} in the sublimation condition.

C3. For each case, evaluate $\ln(P_A/P_{\text{sub}}) = (\mu_{\text{gas}} - \mu_{\text{solid}})/(RT)$ using a hypothetical pure-solid reference. Explain why a negative result with no solid left is not a failed equilibrium calculation. What happens if n_A equals n_{cap} exactly?

Scope: a pure volatile solid, ideal gases, fixed free gas volume, no chemical reaction, no adsorption, and a specified valid sublimation-pressure relation. A numerical balance does not validate these assumptions for a real substance.

Investigate Lab 10 independently

Page 3 | D1: 5-minute prediction at slide 15. Watch slide 16. D2-D4: 22-minute rerun at slide 18.

[Open Lab 10: Solid equilibria](#)

D1. Predict before the demonstration

Use $T=300\text{ K}$, $V=1\text{ L}$, $T_{\text{ref}}=300\text{ K}$, $P_{\text{ref}}=10\text{ kPa}$, $\Delta H_{\text{sub}}=50000\text{ J/mol}$ and the declared T range 250-350 K. Predict the cases below before watching slide 16. These are synthetic definitions, not real property data.

Case	n_A / mol	n_{inert} / mol	Your phase / pressure prediction
10A	0.010	0	
10B	0.002	0	
10C	0.002	0.002	

D2. Reproduce three cases

Follow guide pages 1-2. Select **GSE • sublimation in a rigid vessel**, confirm every input above and calculate. Change only inventory from 10A to 10B, then only inert gas from 10B to 10C. Calculate again after each change. Record unrounded JSON values if a tight balance needs more precision.

Case	P_A / P_{total} (kPa)	n_{gas} / n_{solid} (mol)	Present phases / balance residual
10A			
10B			
10C			

D3. Independently calculate n_{cap} and check all three balances. Inspect both pressure and amount plots: identify temperature on the horizontal axis, the declared range, and the condition where actual partial pressure stops following P_{sub} . Annotate one plot, including its case and axes.

D4. Export each study and save a comparison. Reopen its JSON in Study workspace, restore a case, verify its settings and recalculate. Compare the fresh result with your record. Explain one corrected prediction, one assumption and why equal chemical potentials need not be imposed on an absent solid.

Keep the prediction table, results, hand balance, annotated plot and three exports. Export saves locally; it does not submit work. Use guide page 2 if a result disappears after changing inputs or restoring a case. Then take the 10-minute break at slide 20.

Calculate uptake and predict a vessel

Page 4 | E1-E3: slide 25, 10 min. F1-F3: slide 29, 5 min. Predict before the Lab 11 demonstration.

E. Henry and Langmuir at the same temperature

At $T=300\text{ K}$, $q_s=2\text{ mol/kg}$ and $b=0.1\text{ kPa}^{-1}$. Langmuir: $q=q_s bP/(1+bP)$. Its matched low-pressure Henry coefficient is $KH=q_s b=0.2\text{ mol kg}^{-1}\text{ kPa}^{-1}$, with $q_H=KH P$. P is adsorbate partial pressure and q is absolute uptake per kg of adsorbent.

E1. Calculate q_{Langmuir} and q_{Henry} at $P=5$ and 40 kPa . Include units and surface coverage $\theta=q_{\text{Langmuir}}/q_s$.

P / kPa	Langmuir $q / \text{mol kg}^{-1}$	Henry $q / \text{mol kg}^{-1}$	θ
5			
40			

E2. Compare bP with 1 in both cases. Why does matching the zero-pressure slope not make the models interchangeable at these pressures?

E3. Predict each model as P increases without bound. Does a Langmuir fit alone prove homogeneous sites or a specific adsorption mechanism?

F. A worked balance, then a new prediction

Worked example (slide 28): Langmuir $q_s=2$, $b=0.1$, $T=300\text{ K}$, $V_g=1\text{ L}$, $m_s=10\text{ g}=0.010\text{ kg}$ and specified $P=10\text{ kPa}$. $q=1\text{ mol/kg}$, $n_{\text{gas}}=PV_g/(RT)=0.00400908\text{ mol}$, $n_{\text{ads}}=mq_s=0.0100\text{ mol}$, so $n_A=0.01400908\text{ mol}$. This known-pressure example is **not** the next Lab inventory.

F1. For Lab 11, keep those parameters but set $n_A=0.0100\text{ mol}$, no inert gas. Predict whether the equilibrium P is below or above 10 kPa . Explain using the worked balance, without solving yet.

F2. Predict how replacing Langmuir with the matched Henry model changes P at this fixed total inventory. Explain the gas-plus-adsorbed balance.

F3. For Langmuir, double adsorbent mass from 10 to 20 g at fixed n_A, T, V_g . Predict the pressure direction. Distinguish uptake per kg from total adsorbed moles.

Watch slide 30 after writing the three predictions. Use absolute adsorption and accessible free gas volume in $n_A=PV_g/(RT)+mq(P)$; excess uptake cannot be substituted without its volume/basis correction.

Investigate Lab 11 independently

Page 5 | Slide 32: 24-minute independent rerun | Use Lab guide pages 3-4.

[Open Lab 11: Adsorption equilibrium](#)

G1. Establish a reproducible model study

Use the **Explore isotherms** controls, not the fitting section. Synthetic definitions at 300 K: $q_s=2$ mol/kg, $b=0.1$ kPa⁻¹, Henry $K=0.2$ mol kg⁻¹ kPa⁻¹. Set plotted pressure range 0-100 kPa, free volume 1 L, total adsorbate 0.0100 mol, inert gas 0 and adsorbent mass 10 g. Keep other model parameters at their synthetic defaults; Freundlich and BET are optional comparisons, not required fitted models.

Calculate **11A: Langmuir / 10 g**. Save it. For **11B**, change only the selected vessel model to Henry, calculate and save. Return to Langmuir and change only the mass to 20 g for **11C**; calculate and save.

Case	PA / kPa	q / mol kg ⁻¹	ngas / mol	nads / mol
11A: Langmuir, 10 g				
11B: Henry, 10 g				
11C: Langmuir, 20 g				

G2. For each case, independently substitute its pressure into $q(P)$, $ngas=PV_g/(RT)$, and $nads=msq$. Verify $nA=ngas+nads$. Use ms in kg and the same pressure basis as b or KH . Explain any rounding residual.

G3. Compare each result with F1-F3. Explain why lower q per kg can coexist with more total adsorbed material when mass increases. Annotate the isotherm graph with the low-pressure slope and a finite-pressure departure; a single curve is not a kinetic prediction.

G4. Export all three model studies, save the comparison JSON, import it into Study workspace, restore one case and recalculate. Check units, model, mass and inventory before comparing the fresh result. Keep one numerical balance, an interpretation and a model limitation with the export.

If the vessel result is unavailable, read its message and check whether the equilibrium root lies inside the declared pressure range. Do not substitute a boundary pressure or call an unavailable result zero. Experimental fitting, BET screening and isosteric heat are optional extensions outside this core lesson.

Transfer, review and submit feedback

Page 6 | H1-H4: slide 36, 20 min. I: slide 39, 10 min. Keep solutions closed until the H attempt is complete.

H. New cases, your own calculations

H1. A closed GSE vessel has $T=310\text{ K}$, $V=2\text{ L}$, $P_{\text{sub}}=5\text{ kPa}$ and no inert gas. For $n_A=0.002$ and 0.008 mol , calculate n_{cap} , n_{gas} , n_{solid} and P_A . Identify the phases and verify each inventory balance.

H2. Add 0.001 mol inert gas to each H1 case at fixed T, V . Calculate P_{total} and state whether P_A changes. Explain which equilibrium condition is an equality while solid is present.

H3. A synthetic Langmuir model at 310 K has $q_s=3\text{ mol/kg}$ and $b=0.05\text{ kPa}^{-1}$. At $P=20\text{ kPa}$, $V_g=2\text{ L}$ and $m_s=5\text{ g}$, calculate q , n_{gas} , n_{ads} and the total adsorbate n_A needed for that pressure. Show the kg and pressure conversions.

H4. Keeping the H3 total inventory, T and free gas volume fixed, double adsorbent mass to 10 g . Predict the pressure direction and justify it with the balance; no numerical root is required. Give one assumption shared by the GSE and adsorption calculations and one difference between their physical descriptions.

[After attempting H1-H4: open worked solutions](#)

I. Exit ticket, feedback and saved evidence

Use the existing Session 4 form during the 10-minute pause on slide 39. Answer its **concept** question using the finite solid inventory and partial-pressure condition. In the **evidence** answer include one Lab 10 comparison and one Lab 11 balance, with settings and units. In the existing feedback text, give your actual study minutes, pacing and any unclear step. Submit once and wait for **Response received**. On slide 40 verify the receipt and save the worksheet, corrections and exports; do not resubmit.



Session 4 exit ticket + feedback

Scan the QR or use the clickable link below. The form is anonymous. It is not an attendance-identification form.

[Open the Session 4 form](#)