Moving Up and Down Bloom's Taxonomy

Sample Problems[1]

Diffusion

1. A sheet of steel 1.5 mm thick has N_2 atmospheres on both sides at 1200 °C and is permitted to achieve a steady–state diffusion condition. The D_{N2} at 1200 °C is $6(10^{11})$ m^2/s and the diffusion flux is found to be $1.2(10^{-7})$ kg/m^2-s. In addition, it is known that C_{N2} in the steel at the high-pressure surface is 4 kg/m^3.

How far into the sheet from this high-pressure side will the concentration be 2.0 kg/m^3? Assume a linear concentration profile.

<u>Current levels</u>
recognize [1.1], classify [2.3], execute [3.1]

<u>Moving up Bloom's</u>
A. Don't tell them D_{N2} value – must use tabulated info/data. *infer [2.5], differentiate [4.1]*
B. Don't tell them linear concentration profile. *differentiate [4.1]*
C. Determine how long before s.s. is reached *evaluate [5]*
D. Don't tell them steady state. *evaluate [5]*
E. Sketch concentration profile. *evaluate [5]*
F. Sketch profile evolution *before* steady state is reached. *evaluate [5]*

<u>Moving down Bloom's</u>
A. Give equation
B. Show profile. *Recognize [1.1]*
C. Ask them to define steady state. *Recognize [1.1]*
D. Units of flux. *Remember [1]*

[1] You'll notice that most STEM problems that involve calculations are at the 3.1 – execute – level. Obviously, some problems are more nuanced than others and even though a strict "plug and chug" problem is technically still at 3.1, it's procedurally easier than a calculation that requires estimations, or other decisions about values, etc.

2. Show that:

$$C(r) = \frac{\alpha}{r} + \beta$$

is a solution to the diffusion equation in spherical coordinates:

$$D\left(\frac{\partial^2 C}{\partial r^2} + \frac{2}{r}\frac{\partial C}{\partial r}\right) = 0$$

where *a* and *b* are constants.

<u>Current levels</u>
execute [3.1], recognize [1.1]

<u>Moving Up Bloom's</u>
A. Ask them to solve in spherical coords. *execute [3.1] (harder)*
B. Sketch solution. *evaluate [3]*
C. Comment on constants. *critiquing (judging) [5.2]*

<u>Moving Down Bloom's</u>
A. Ask them to differentiate and substitute to show that the solution given solves the equation. *execute [3.1] (easier)*
B. Give a set of values of r and C and ask student to plot. *classify [2.3], explain [2.7]*
C. Sketch what the diffusion profile will look like at various times/depths. *classify [2.3], explain [2.7]*

3. Boron nitride wafers are used in conjunction with silicon wafers in a deposition step. Q = 2.25 (10^{13}) boron atoms/cm^2 are deposited on the surface of a silicon slice. The slice is subsequently placed in a diffusion furnace at 1145 °C for 2 hours. The n-type epi-layer into which the boron diffuses has an impurity concentration N_D equal to 1(10^{16}) atoms/cm^3. Assuming that the diffusion is Gaussian, find the depth of the p-n junction in mm.
The junction occurs where the background concentration = the boron concentration.

<u>Current levels</u>
execute [3.1], recall [1.2]

<u>Moving Up Bloom's</u>
A. Don't specifiy Gaussian (exp) *differentiate [4.1]*

<u>Moving Down Bloom's</u>
A. Define n-type and p-type *recall [1.2]*
B. what atoms would you have to add to make it n-type? *recall [1.2]*
C. provide criteria for junction location *differentiate [4.1]*

Thermodynamics

1. Compute the change in Gibbs free energy of 1 mole of MgO when it is heated from 298 K to 1300 K at 1 atm.

   Use:

$$C_P = 48.99 + 3.43(10^{-3})T - \frac{11.34(10^{-5})}{T^2}(J/mol \bullet K)$$

$$S^{o}_{298} = 26.9 \;\; J/mol \cdot K$$

Use:

$$dS = \frac{C_P}{T}dT - V\alpha dP$$

(assume $dP = 0$)

Current levels

execute [3.1], infer [2.5], recall [1.2]

Moving Up Bloom's

A. Don't give dS expression *recognize/recall [1], differentiate [4.1]*
B. Don't state dP=0 assumption - *differentiate [4.1]*
C. What TD values are necessary to compute this problem? *differentiate [4.1]*
D. Find valid expression for Cp - *differentiate [4.1]*

Moving Down Bloom's

A. Evaluate integral – *recognize [1.1]*
B. Define G – *recall [1.2]*

2. At 1 atm pressure, pure Ge melts at 1231 K and boils at 2980 K. The pressure at the triple point (S, L, G) is $8.4(10^{-8})$ atm. Estimate the enthalpy of vaporization.

Current levels

Infer [2.5]

Moving Up Bloom's

A. Do not state problem, rather, ask: "In order to calculate enthalpy of vaporization – what information do you need?" *infer [2.5], explain [2.7], differentiate [4.1]*

B. Design an *experiment* to measure the enthalpy of vaporization *infer [2.5], explain [2.7], differentiate[4.1]*

Moving Down Bloom's
A. Describe what happens when something melts *Recall [1.2]*

3. List the kinds of energy conversions involved in:
   - Operating a calculator
   - Propelling an automobile
   - Using your arm to turn a page in a book

Recognize [1.1], recall [1.2], classify [2.3]

Moving Up Bloom's
Estimate the amount of energy required to: *differentiate [4.1], execute [3.1]*

Moving Down Bloom's
Write out choices (chemical), other?
What is energy…
Recognize [1.1], recall [1.2]

Materials Science

1. The average grain diameter for a brass material was measured as a function of time at 650 °C – and is tabulated below at 2 different times:

Time (min.)	**Grain Diameter (mm)**
30	$3.9\ (10^{-2})$
90	$6.6\ (10^{-2})$

Using :

$$d^{n} - d_o^{n} = K\, t$$

where n and K are constants

a. Calculate the original average grain diameter d_o
b. Predict the average grain diameter after 150 minutes at 650 °C.

Current levels
execute [3.1]

Moving Up Bloom's
A. Give messier data organize/differentiate [4.1/4.2]
B. Design/describe an experiment wherein you could measure the grain size as a function of time. *Generate [6.1], plan [6.2]*

Moving Down Bloom's
A. Give k, n *recognize [1.1]*

2. For cubic crystals, as the values of the planar indices h, k and l increase, does the distance between adjacent, parallel planes (the interplanar spacing) increase or decrease? Please explain your answer.

<u>Current levels</u>
explain [2.7]

<u>Moving Up Bloom's</u>
A. Calculation, then ask to describe *Execute [3.1]*
B. Ask about hexagonal *differentiate [4.1], infer [2.5]*

<u>Moving Down Bloom's</u>
A. Define interplanar spacing *recall [1.2]*

Kinematics
1. A motorcycle patrolman starts from rest at point A two seconds after a car, speeding at the constant rate of 120 km/h, passes point A. If the patrolman accelerates at the rate of 6 m/s^2 until he reaches his maximum permissible speed of 150 km/h, which he maintains, calculate the distance x from point A to the point where he overtakes the car.

<u>Current levels</u>
execute [3.1]

<u>Moving Up Bloom's</u>
A. Leave out info about acceleration of patrolman & maximum speed *differentiate [4.1]*

<u>Moving Down Bloom's</u>
A. Define acceleration, velocity *recall [1.2]*

Revised Bloom's Taxonomy – Categories (from less to more complex)

1. REMEMBERING

Recognize, list, describe, identify retrieve, name ….
Can the student RECALL information?

Recognizing
Locating knowledge in memory that is consistent with presented material.
Synonyms: Identifying...

Recalling
Retrieving relevant knowledge from long-term memory.
Synonyms: Retrieving... Naming...

2. UNDERSTANDING

Interpret, exemplify, summarize, infer, paraphrase ….
Can the student EXPLAIN ideas or concepts?

Interpreting
Changing from one form of representation to another
Synonyms : Paraphrasing… Translating,...Representing,… Clarifying...

Exemplifying
Finding a specific example or illustration of a concept or principle
Synonyms : Instantiating… Illustrating...

Classifying
Determining that something belongs to a category (e.g., concept or principle).
Synonyms : Categorizing...Subsuming...

Summarizing
Drawing a logical conclusion from presented information.
Synonyms : Abstracting… Generalizing...

Inferring
Abstracting a general theme or major point
Synonyms : Extrapolating… Interpolating.. Predicting… Concluding…

Comparing
Detecting correspondences between two ideas, objects, etc
Synonyms : Contrasting… Matching ...Mapping...

Explaining
Constructing a cause-and-effect model of a system.
Synonyms : Constructing models...

3. APPLYING

Implement, carry out, use …
Can the student USE the new knowledge in another familiar situation?

Executing
Applying knowledge (often procedural) to a routine task.
Synonyms : Carrying out…

Implementing
Applying knowledge (often procedural) to a non-routine task.
Synonyms : Using.

4. ANALYZING

Compare, attribute, organize, deconstruct …
Can the student DIFFERENTIATE between constituent parts?

Differentiating
Distinguishing relevant from irrelevant parts or important from unimportant parts of presented material.
Synonyms : Discriminating, Selecting, Focusing, Distinguishing,
Organizing
Determining how elements fit or function within a structure.
Synonyms : Outlining, Structuring, Integrating, Finding coherence
Attributing
Determining the point of view, bias, values, or intent underlying presented material.
Synonyms : Deconstructing

5. EVALUATING
Check, critique, judge hypothesize ...
Can the student JUSTIFY a decision or course of action?
Checking
Detecting inconsistencies or fallacies within a process or product. Determining whether a process or product has internal consistency.
Synonyms : Testing, Detecting, Monitoring
Critiquing
Detecting the appropriateness of a procedure for a given task or problem.
Synonyms : Judging

6. CREATING
Design, construct, plan, produce ...
Can the student GENERATE new products, ideas or ways of viewing things?
G**enerating**
Coming up with alternatives or hypotheses based on criteria
Synonyms : Hypothesizing
Planning
Devising a procedure for accomplishing some task. producing
Synonyms : Designing
Producing
Inventing a product.
Synonyms : Constructing

5.95J / 6.982J / 7.59J / 8.395J / 18.094J / 1.95J / 2.978J Teaching College-Level Science and Engineering
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