
 NUMERICAL ANSWERS TO ASSIGNED TUTORIAL PROBLEM SETS FOR CHEM206
 FROM KOTZ & TREICHEL'S CHEMISTRY & CHEMICAL REACTIVITY, 6th Ed.

NOTE: the answers from Ch.19 have not been verified. Please report any errors.

Ch.	Q#	Answer	Units	SFs	Comments
19	2a	impure Si			
19	2b	O ₂ (g) at 0°C			
19	2c	iodine gas			
19	2d	at lower P			
19	8	-99.1	J/K	3	
19	12	-15.4	J/K	3	
19	16	318.9	J/K	4	$\Delta S_{\text{universe}} > 0 \Rightarrow$ spontaneous
19	18	spontaneous at all temperatures			
19	18	favoured at high temperatures			
19	22a	-431.16	kJ	5	ΔH°
19	22a	-125.3	J/K	4	ΔS°
19	22a	-393.8	kJ	5	$\Delta G^\circ < 0$; product favoured (fwd rxn is spont.); enthalpy-driven
19	22b	49.03	kJ	4	ΔH°
19	22b	-252.4	J/K	4	ΔS°
19	22b	124.3	kJ	4	$\Delta G^\circ > 0$; <u>reverse</u> rxn is spontaneous; driven in reverse by H & S
19	26a	-249.5	kJ	4	product-favoured
19	26b	-990.32	kJ	5	product-favoured
19	30a	100.89	J/K	5	entropy-favoured; higher T \Rightarrow more products
19	30b	-187.95	J/K	5	entropy-disfavoured; higher T \Rightarrow more reactants...
19	30c	315.5	J/K	4	entropy-favoured; higher T \Rightarrow more products
		note: SiCl ₄ is (g), not (l)			
19	30d	15.7	J/K	3	entropy-favoured; higher T \Rightarrow more products
19	32	2141	K	4	this T or higher is necessary
19	34	2.5×10^{-29}	unitless	2	$=K_p$; large positive ΔG° implies K_p value $\ll 1$
19	36	4.0×10^{14}	unitless	2	$=K_p$; large negative ΔG° & $K_p \gg 1$ indicate product-favoured.
19	38	-125.52	kJ	5	ΔH°
19	38	-129.9	J/K	4	ΔS°
19	38	-86.81	kJ	4	$\Delta G^\circ =$ negative; product-favoured under std. conditions
19	42a	43.4	J/K	3	$= \Delta S_{\text{sys}}^\circ$
		3.85	kJ	3	$= \Delta H^\circ$
		-12.9	J/K	3	$= \Delta S_{\text{surr}}^\circ = -\Delta H^\circ/T$
		30.5	J/K	3	$= \Delta S_{\text{univ}}$ This process is product-favoured, & entropy-driven.

Ch.	Q#	Answer	Units	SFs	Comments
19	42b	-16.4 -43.22 145.0 128.6	J/K kJ J/K J/K	3 4 4 4	= $\Delta S_{\text{sys}}^\circ$ = ΔH° = $\Delta S_{\text{surr}}^\circ = -\Delta H^\circ/T$ = $\Delta S_{\text{univ}}^\circ$ This process is product-favoured, & enthalpy-driven.
19	48	At the normal boiling point, 78°C, the vapour pressure of ethanol is 1.0 atm, <i>i.e.</i> , $P_{\text{vap-1}} = P_{\text{ext}}$. Use the Clausius-Clapeyron equation, section 13.5 (& see question 19.45, $\Delta H_{\text{vap}}^\circ = 39.3$ kJ/mol). Thus: the vapour pressure at 37°C = $P_{\text{vap-2}} = 128$ mm Hg.			
19	50	At equilibrium, $\Delta G^\circ = 0 = -RT \ln K_p$ where $K_p = 1.00$ (although this relationship is not helpful here!) $\Delta G^\circ = 0 = \Delta H^\circ - T\Delta S^\circ$ is the useful here (where $\Delta H^\circ = 179.0$ kJ)...thus: $\Delta H^\circ = T\Delta S^\circ$ or, $\Delta S^\circ = \Delta H^\circ/T$. Assuming the values of ΔH° and ΔS° do not change between 298K & 1170K (not necessarily true!), $\Delta S^\circ = \Delta H^\circ/T = 153.1$ J/K·mol.			
19	60a	91.42	kJ	4	= ΔG°
	60b	9.5×10^{-17}	unitless	2	= K_p
	60c	131.31	kJ	5	= ΔH°
		133.9	J/K	4	= ΔS°
		At 298K, the reaction is not spontaneous. To find T above which it will be spont., set $\Delta G^\circ = 0$. Solve for $T = \Delta H^\circ/\Delta S^\circ = 980.4$ K = 707.3°C			
19	62a	161.61	J/K	5	$\Delta S^\circ > 0$ matches liquid \rightarrow gases
19	62b	115.3	kJ	4	$\Delta G^\circ > 0$ therefore non-spont. (<i>i.e.</i> , reverse rxn is spont.)
19	62c	739	°C	3	lowest T at which fwd rxn is spontaneous
19	64	For reaction that forms hydrated calcium sulfite:			
		-39.8	J/K	3	= ΔS°
		-57.9	kJ	3	= ΔH°
		-46.0	kJ	3	= ΔG° at 298 K
		For reaction that forms hydrated calcium sulfate:			
		-128.9	J/K	4	= ΔS°
		-320.8	kJ	4	= ΔH°
		-282.4	kJ	4	= ΔG° at 298 K
		Thus, the 2 nd reaction is more product-favoured.			
19	68a	-62.2 -132.7 -22.64	kJ J/K kJ	3 4 4	= ΔH° note: per 2 mole Ag_2O ... = ΔS° = ΔG°
	68b	9.3×10^3	unitless	2	= $K_p = 1/P_{\text{O}_2}$ So, $P_{\text{O}_2} = 1.1 \times 10^4$ atm.
	68c	469	K	3	= T at which $\Delta G^\circ = 0$, so $T = \Delta H^\circ/\Delta S^\circ$
		This corresponds to equilibrium where all substances are in standard states, which for O_2 or any other gas involved means partial pressure of 1 bar. The answer can be found by starting from $P_{\text{O}_2} = 1$ atm \approx 1 bar, so $K_p = 1/P_{\text{O}_2} = 1$. If now solve for ΔG° , we find $\Delta G^\circ = 0$, so $T = \Delta H^\circ/\Delta S^\circ$ $T = 196^\circ\text{C}$			
19	74a	The entropy of the universe increases in all product-favoured reactions.			
	74b	Product-favoured reactions can occur at any rate, not necessarily at a fast rate.			
	74c	While many spontaneous processes are exothermic, endothermic processes can be spontaneous at high temperatures.			
	74d	Endothermic processes can be spontaneous at high temperatures.			

Ch.	Q#	Answer	Units	SFs	Comments
19	80a	positive (endothermic)			
	80b	positive (solid → liquid)			
	80c	zero (equilibrium)			
	80d	positive (reactant-favoured)			
	80e	negative (product-favoured)			
19	82a	+ + +			
19	82b	- + -			
19	82c	- + -			
19	86a	2.8	kJ	2	$\Delta G^\circ = \text{positive}$; rxn does not occur on its own <u>at std.cond.!</u>
19	86b				high T,P used to overcome unfavourable thermodynamics
19	87	See solutions manual			