

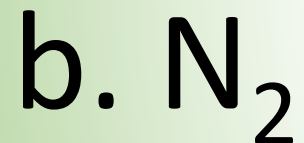
TUTORIAL:

Ikatan Kimia I

(Bab 9)

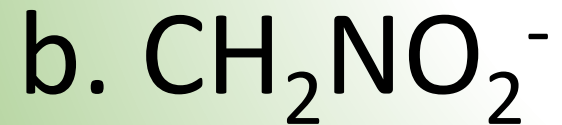
Soal No. 1

Tuliskan struktur Lewis untuk:



Soal No. 2

Tuliskan struktur Lewis untuk spesi berikut, termasuk semua bentuk resonansinya dan berikan muatan formalnya:



Soal No. 3

Molekul BF_3 memiliki oktet yang tidak lengkap di sekitar atom B. Gambarkan keempat struktur resonansinya, tunjukkan mana struktur resonansi yang paling stabil dan jelaskan alasannya.

Soal No. 4

Gambarlah ketiga struktur resonansi ion OCN^- . Berikan muatan formalnya dan tunjukkan struktur resonansi yang paling stabil.

Soal No. 5

9.69 From the following data, calculate the average bond enthalpy for the N—H bond:



Soal No. 6

9.72 For the reaction



- Predict the enthalpy of reaction from the average bond enthalpies in Table 9.4.
- Calculate the enthalpy of reaction from the standard enthalpies of formation (see Appendix 3) of the reactant and product molecules, and compare the result with your answer for part (a).

TABLE 9.4

Some Bond Enthalpies of Diatomic Molecules* and Average Bond Enthalpies for Bonds in Polyatomic Molecules

Bond	Bond Enthalpy (kJ/mol)	Bond	Bond Enthalpy (kJ/mol)
H—H	436.4	C—S	255
H—N	393	C=S	477
H—O	460	N—N	193
H—S	368	N=N	418
H—P	326	N≡N	941.4
H—F	568.2	N—O	176
H—Cl	431.9	N=O	607
H—Br	366.1	O—O	142
H—I	298.3	O=O	498.7
C—H	414	O—P	502
C—C	347	O=S	469
C=C	620	P—P	197
C≡C	812	P=P	489
C—N	276	S—S	268
C=N	615	S=S	352
C≡N	891	F—F	156.9
C—O	351	Cl—Cl	242.7
C=O [†]	745	Br—Br	192.5
C—P	263	I—I	151.0

*Bond enthalpies for diatomic molecules (in color) have more significant figures than bond enthalpies for bonds in polyatomic molecules because the bond enthalpies of diatomic molecules are directly measurable quantities and not averaged over many compounds.

[†]The C=O bond enthalpy in CO₂ is 799 kJ/mol.

APPENDIX 3

Inorganic Substances

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/K · mol)
Ag(s)	0	0	42.7
Ag ⁺ (aq)	105.9	77.1	73.9
AgCl(s)	−127.0	−109.7	96.1
AgBr(s)	−99.5	−95.9	107.1
AgI(s)	−62.4	−66.3	114.2
AgNO ₃ (s)	−123.1	−32.2	140.9
Al(s)	0	0	28.3
Al ³⁺ (aq)	−524.7	−481.2	−313.38
Al ₂ O ₃ (s)	−1669.8	−1576.4	50.99
As(s)	0	0	35.15
AsO ₄ ^{3−} (aq)	−870.3	−635.97	−144.77
AsH ₃ (g)	171.5		
H ₃ AsO ₄ (s)	−900.4		
Au(s)	0	0	47.7
Au ₂ O ₃ (s)	80.8	163.2	125.5
AuCl(s)	−35.2		
AuCl ₃ (s)	−118.4		
B(s)	0	0	6.5
B ₂ O ₃ (s)	−1263.6	−1184.1	54.0
H ₃ BO ₃ (s)	−1087.9	−963.16	89.58
H ₃ BO ₃ (aq)	−1067.8	−963.3	159.8
Ba(s)	0	0	66.9
Ba ²⁺ (aq)	−538.4	−560.66	12.55
BaO(s)	−558.2	−528.4	70.3
BaCl ₂ (s)	−860.1	−810.66	125.5
BaSO ₄ (s)	−1464.4	−1353.1	132.2
BaCO ₃ (s)	−1218.8	−1138.9	112.1
Be(s)	0	0	9.5
BeO(s)	−610.9	−581.58	14.1
Br ₂ (l)	0	0	152.3
Br [−] (aq)	−120.9	−102.8	80.7
HBr(g)	−36.2	−53.2	198.48
C(graphite)	0	0	5.69
C(diamond)	1.90	2.87	2.4
CO(g)	−110.5	−137.3	197.9
CO ₂ (g)	−393.5	−394.4	213.6
CO ₂ (aq)	−412.9	−386.2	121.3
CO ₃ ^{2−} (aq)	−676.3	−528.1	−53.1

*The thermodynamic quantities of ions are based on the reference states that $\Delta H_f^\circ[\text{H}^+(aq)] = 0$, $\Delta G_f^\circ[\text{H}^+(aq)] = 0$, and $S^\circ[\text{H}^+(aq)] = 0$ (see p. 807).

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/K · mol)
HCO ₃ [−] (aq)	−691.1	−587.1	94.98
H ₂ CO ₃ (aq)	−699.7	−623.2	187.4
CS ₂ (g)	115.3	65.1	237.8
CS ₂ (l)	87.3	63.6	151.0
HCN(aq)	105.4	112.1	128.9
CN [−] (aq)	151.0	165.69	117.99
(NH ₂) ₂ CO(s)	−333.19	−197.15	104.6
(NH ₂) ₂ CO(aq)	−319.2	−203.84	173.85
Ca(s)	0	0	41.6
Ca ²⁺ (aq)	−542.96	−553.0	−55.2
CaO(s)	−635.6	−604.2	39.8
Ca(OH) ₂ (s)	−986.6	−896.8	83.4
CaF ₂ (s)	−1214.6	−1161.9	68.87
CaCl ₂ (s)	−794.96	−750.19	113.8
CaSO ₄ (s)	−1432.69	−1320.3	106.69
CaCO ₃ (s)	−1206.9	−1128.8	92.9
Cd(s)	0	0	51.46
Cd ²⁺ (aq)	−72.38	−77.7	−61.09
CdO(s)	−254.6	−225.06	54.8
CdCl ₂ (s)	−389.1	−342.59	118.4
CdSO ₄ (s)	−926.17	−820.2	137.2
Cl ₂ (g)	0	0	223.0
Cl [−] (aq)	−167.2	−131.2	56.5
HCl(g)	−92.3	−95.27	187.0
Co(s)	0	0	28.45
Co ²⁺ (aq)	−67.36	−51.46	155.2
CoO(s)	−239.3	−213.38	43.9
Cr(s)	0	0	23.77
Cr ²⁺ (aq)	−138.9		
Cr ₂ O ₃ (s)	−1128.4	−1046.8	81.17
CrO ₄ ^{2−} (aq)	−863.16	−706.26	38.49
Cr ₂ O ₇ ^{2−} (aq)	−1460.6	−1257.29	213.8
Cs(s)	0	0	82.8
Cs ⁺ (aq)	−247.69	−282.0	133.05
Cu(s)	0	0	33.3
Cu ⁺ (aq)	51.88	50.2	−26.4
Cu ²⁺ (aq)	64.39	64.98	−99.6
CuO(s)	−155.2	−127.2	43.5
Cu ₂ O(s)	−166.69	−146.36	100.8
CuCl(s)	−134.7	−118.8	91.6
CuCl ₂ (s)	−205.85	?	?
CuS(s)	−48.5	−49.0	66.5
CuSO ₄ (s)	−769.86	−661.9	113.39
F ₂ (g)	0	0	203.34
F [−] (aq)	−329.1	−276.48	−9.6
HF(g)	−271.6	−270.7	173.5
Fe(s)	0	0	27.2
Fe ²⁺ (aq)	−87.86	−84.9	−113.39

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/K · mol)
Fe ³⁺ (aq)	−47.7	−10.5	−293.3
FeO(s)	−272.0	−255.2	60.8
Fe ₂ O ₃ (s)	−822.2	−741.0	90.0
Fe(OH) ₂ (s)	−568.19	−483.55	79.5
Fe(OH) ₃ (s)	−824.25	?	?
H(g)	218.2	203.2	114.6
H ₂ (g)	0	0	131.0
H ⁺ (aq)	0	0	0
OH [−] (aq)	−229.94	−157.30	−10.5
H ₂ O(g)	−241.8	−228.6	188.7
H ₂ O(l)	−285.8	−237.2	69.9
H ₂ O ₂ (l)	−187.6	−118.1	?
Hg(l)	0	0	77.4
Hg ²⁺ (aq)		−164.38	
HgO(s)	−90.7	−58.5	72.0
HgCl ₂ (s)	−230.1		
Hg ₂ Cl ₂ (s)	−264.9	−210.66	196.2
HgS(s)	−58.16	−48.8	77.8
HgSO ₄ (s)	−704.17		
Hg ₂ SO ₄ (s)	−741.99	−623.92	200.75
I ₂ (s)	0	0	116.7
I [−] (aq)	−55.9	−51.67	109.37
HI(g)	25.9	1.30	206.3
K(s)	0	0	63.6
K ⁺ (aq)	−251.2	−282.28	102.5
KOH(s)	−425.85		
KCl(s)	−435.87	−408.3	82.68
KClO ₃ (s)	−391.20	−289.9	142.97
KClO ₄ (s)	−433.46	−304.18	151.0
KBr(s)	−392.17	−379.2	96.4
KI(s)	−322.65	−322.29	104.35
KNO ₃ (s)	−492.7	−393.1	132.9
Li(s)	0	0	28.0
Li ⁺ (aq)	−278.46	−293.8	14.2
Li ₂ O(s)	−595.8	?	?
LiOH(s)	−487.2	−443.9	50.2
Mg(s)	0	0	32.5
Mg ²⁺ (aq)	−461.96	−456.0	−117.99
MgO(s)	−601.8	−569.6	26.78
Mg(OH) ₂ (s)	−924.66	−833.75	63.1
MgCl ₂ (s)	−641.8	−592.3	89.5
MgSO ₄ (s)	−1278.2	−1173.6	91.6
MgCO ₃ (s)	−1112.9	−1029.3	65.69
Mn(s)	0	0	31.76
Mn ²⁺ (aq)	−218.8	−223.4	−83.68
MnO ₂ (s)	−520.9	−466.1	53.1
N ₂ (g)	0	0	191.5
N ₃ [−] (aq)	245.18	?	?

APPENDIX 3

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/K · mol)
NH ₃ (g)	−46.3	−16.6	193.0
NH ₄ ⁺ (aq)	−132.80	−79.5	112.8
NH ₄ Cl(s)	−315.39	−203.89	94.56
NH ₃ (aq)	−80.3	−26.5	111.3
N ₂ H ₄ (l)	50.4		
NO(g)	90.4	86.7	210.6
NO ₂ (g)	33.85	51.8	240.46
N ₂ O ₄ (g)	9.66	98.29	304.3
N ₂ O(g)	81.56	103.6	219.99
HNO ₂ (aq)	−118.8	−53.6	
HNO ₃ (l)	−173.2	−79.9	155.6
NO ₃ [−] (aq)	−206.57	−110.5	146.4
Na(s)	0	0	51.05
Na ⁺ (aq)	−239.66	−261.87	60.25
Na ₂ O(s)	−415.9	−376.56	72.8
NaCl(s)	−411.0	−384.0	72.38
NaI(s)	−288.0		
Na ₂ SO ₄ (s)	−1384.49	−1266.8	149.49
NaNO ₃ (s)	−466.68	−365.89	116.3
Na ₂ CO ₃ (s)	−1130.9	−1047.67	135.98
NaHCO ₃ (s)	−947.68	−851.86	102.09
Ni(s)	0	0	30.1
Ni ²⁺ (aq)	−64.0	−46.4	−159.4
NiO(s)	−244.35	−216.3	38.58
Ni(OH) ₂ (s)	−538.06	−453.1	79.5
O(g)	249.4	230.1	160.95
O ₂ (g)	0	0	205.0
O ₃ (aq)	−12.09	16.3	110.88
O ₃ (g)	142.2	163.4	237.6
P(white)	0	0	44.0
P(red)	−18.4	13.8	29.3
PO ₄ ^{3−} (aq)	−1284.07	−1025.59	−217.57
P ₄ O ₁₀ (s)	−3012.48		
PH ₃ (g)	9.25	18.2	210.0
HPO ₄ ^{2−} (aq)	−1298.7	−1094.1	−35.98
H ₂ PO ₄ [−] (aq)	−1302.48	−1135.1	89.1
Pb(s)	0	0	64.89
Pb ²⁺ (aq)	1.6	−24.3	21.3
PbO(s)	−217.86	−188.49	69.45
PbO ₂ (s)	−276.65	−218.99	76.57
PbCl ₂ (s)	−359.2	−313.97	136.4
PbS(s)	−94.3	−92.68	91.2
PbSO ₄ (s)	−918.4	−811.2	147.28
Pt(s)	0	0	41.84
PtCl ₄ ^{2−} (aq)	−516.3	−384.5	175.7
Rb(s)	0	0	69.45
Rb ⁺ (aq)	−246.4	−282.2	124.27
S(rhombic)	0	0	31.88

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/K · mol)
S(monoclinic)	0.30	0.10	32.55
SO ₂ (g)	−296.4	−300.4	248.5
SO ₃ (g)	−395.2	−370.4	256.2
SO ₃ ^{2−} (aq)	−624.25	−497.06	43.5
SO ₄ ^{2−} (aq)	−907.5	−741.99	17.15
H ₂ S(g)	−20.15	−33.0	205.64
HSO ₃ [−] (aq)	−627.98	−527.3	132.38
HSO ₄ [−] (aq)	−885.75	−752.87	126.86
H ₂ SO ₄ (l)	−811.3	?	?
SF ₆ (g)	−1096.2	?	?
Si(s)	0	0	18.70
SiO ₂ (s)	−859.3	−805.0	41.84
Sr(s)	0	0	54.39
Sr ²⁺ (aq)	−545.5	−557.3	−39.33
SrCl ₂ (s)	−828.4	−781.15	117.15
SrSO ₄ (s)	−1444.74	−1334.28	121.75
SrCO ₃ (s)	−1218.38	−1137.6	97.07
Zn(s)	0	0	41.6
Zn ²⁺ (aq)	−152.4	−147.2	−106.48
ZnO(s)	−348.0	−318.2	43.9
ZnCl ₂ (s)	−415.89	−369.26	108.37
ZnS(s)	−202.9	−198.3	57.7
ZnSO ₄ (s)	−978.6	−871.6	124.7

Organic Substances				
Substance	Formula	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/K · mol)
Acetic acid(l)	CH ₃ COOH	−484.2	−389.45	159.8
Acetaldehyde(g)	CH ₃ CHO	−166.35	−139.08	264.2
Acetone(l)	CH ₃ COCH ₃	−246.8	−153.55	198.7
Acetylene(g)	C ₂ H ₂	226.6	209.2	200.8
Benzene(l)	C ₆ H ₆	49.04	124.5	172.8
Butane(g)	C ₄ H ₁₀	−124.7	−15.7	310.0
Ethanol(l)	C ₂ H ₅ OH	−276.98	−174.18	161.0
Ethane(g)	C ₂ H ₆	−84.7	−32.89	229.5
Ethylene(g)	C ₂ H ₄	52.3	68.1	219.5
Formic acid(l)	HCOOH	−409.2	−346.0	129.0
Glucose(s)	C ₆ H ₁₂ O ₆	−1274.5	−910.56	212.1
Methane(g)	CH ₄	−74.85	−50.8	186.2
Methanol(l)	CH ₃ OH	−238.7	−166.3	126.8
Propane(g)	C ₃ H ₈	−103.9	−23.5	269.9
Sucrose(s)	C ₁₂ H ₂₂ O ₁₁	−2221.7	−1544.3	360.2

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