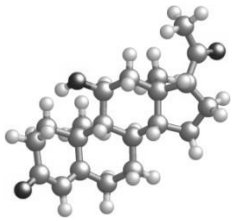


Chem!stry

Name: …… **( )**

Class: ……

Date: …… **/** …… **/** ……

Chemistry Olympiad Training for Secondary School Level – Part Three

1. Which one of the following substances has the highest melting point?

A Li_2O **B** MgO

C CO_2 **D** N_2O_5

2. Which one of the following nitrogen halides is least stable thermodynamically?

A NF_3 **B** NCl_3

C NBr_3 **D** NI_3

3. Which one of the following organic compounds is least soluble in water?

A Butan-1-ol **B** Ethanol

C Methanol **D** Propan-1-ol

4. Use the information provided to calculate the standard enthalpy change of formation for ethyne, $C_2H_2(g)$, in kJ mol^{-1}.

$$C_2H_2(g) + {}^5/_2O_2(g) \rightarrow 2CO_2(g) + H_2O(l) \qquad \Delta H° = -1299.5$$

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H° = -393.5$$

$$H_2(g) + {}^1/_2O_2(g) \rightarrow H_2O(l) \qquad \Delta H° = -285.8$$

A –1978.8 **B** –1121.4

C +226.7 **D** +453.4

5. For a reaction at constant pressure to be spontaneous, which one of the following relationships must be correct?

A $\Delta H_{rxn} < 0$ **B** $\Delta G_{rxn} < 0$

C $\Delta S_{rxn} < 0$ **D** $\Delta S_{univ} < 0$

6. In order to calculate the lattice energy of NaCl using a Born-Haber cycle, which value is not needed?

A The enthalpy of sublimation of Na(s).

B The first ionisation energy of Cl(g).

C The bond dissociation energy of Cl_2(g).

D The enthalpy of formation of NaCl(s).

7. Initial rate data for the reaction **X** + **Y** → **Z** is given in the table below:

[**X**] / mol dm^{-3}	[**Y**] / mol dm^{-3}	Rate / mol dm^{-3} s^{-1}
0.10	0.10	0.020
0.10	0.20	0.080
0.30	0.30	0.540

What is the rate law for this reaction?

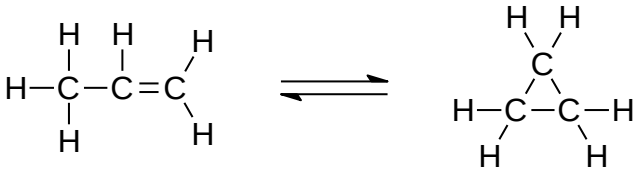
A rate = k[**X**]^2

B rate = k[**Y**]^2

C rate = k[**X**][**Y**]

D rate = k[**X**][**Y**]^2

8. The gas phase reaction shown below is endothermic as written:



Which change(s) will increase the quantity of $CH_3CH{=}CH_2$ at equilibrium?

I Increasing the temperature.

II Increasing the pressure.

A **I** only.

B **II** only.

C Both **I** and **II**.

D Neither **I** nor **II**.

9. Which ion is not isoelectric with argon?

A S^{2-}

B K^{+}

C Sc^{2+}

D Ti^{4+}

10. Which substance will form hydrogen bonds to water molecules but will not form hydrogen bonds with its own molecules?

A HF

B C_2H_5OH

C CH_3NH_2

D CH_3OCH_3

11. What is the number of π-bonds in butenedioic acid, $C_4H_4O_4$?

A 1 **B** 2

C 3 **D** 4

12. In which list are the ions arranged in order of increasing size?

A $F^- < S^{2-} < Al^{3+} < Mg^{2+}$

B $F^- < S^{2-} < Mg^{2+} < Al^{3+}$

C $Mg^{2+} < F^- < Al^{3+} < S^{2-}$

D $Al^{3+} < Mg^{2+} < F^- < S^{2-}$

13. The pH of a saturated solution of $Fe(OH)_2$ is 8.67. What is the K_{sp} for $Fe(OH)_2$?

$$Fe(OH)_2(s) \rightarrow Fe^{2+}(aq) + 2OH^-(aq)$$

$$K_{sp} = [Fe^{2+}(aq)] \times [OH^-(aq)]^2$$

A 5×10^{-6} **B** 2×10^{-11}

C 1×10^{-16} **D** 5×10^{-17}

14. Molecules of which type(s) do not contain a C=O bond?

I Amide

II Amine

III Ether

IV Ester

A **II** only. **B** **I** and **IV** only.

C **II** and **III** only. **D** **III** and **IV** only.

15. Bond energies for hydrogen and nitrogen are given in the table below:

Bond Energies / kJ mol^{-1}	
N≡N	946
N=N	418
N–N	163
N–H	389
H–H	436

What is the ΔH_f° for $N_2H_4(g)$ in kJ mol^{-1}?

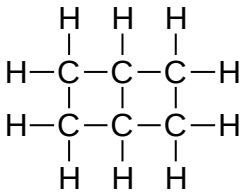
$$N_2(g) + 2H_2(g) \rightarrow N_2H_4(g)$$

A +156 **B** +99

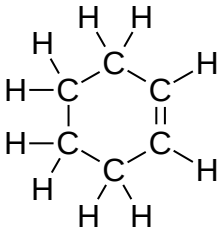
C –99 **D** –156

16. Which isomer of C_6H_{10} is least stable?

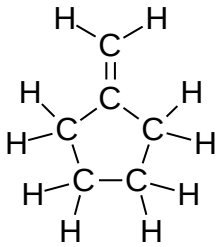
A



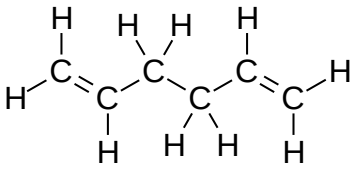
B



C



D



17. The formula for a compound of uranium is given below:

$$UO_2(C_2H_3O_2)_2{\cdot}NH_4C_2H_3O_2{\cdot}6H_2O$$

The relative molecular mass of this compound is 573. What is the percentage, by mass, of oxygen in this compound?

A 5.58%

B 16.8%

C 22.3%

D 39.1%

18. The percentage composition of the high explosive HNS is given in the table below:

C	H	N	O
37.35%	1.34%	18.67%	42.65%

The relative molecular mass of HNS is 450.22. What is the molecular formula of HNS?

A $C_{13}H_4N_7O_{12}$

B $C_{14}H_6N_6O_{12}$

B $C_{15}H_{10}N_6O_{11}$

C $C_{16}H_{12}N_5O_{11}$

19. In an operating voltaic cell, electrons move through the external circuit and ions move through the electrolyte solution. Which one of the following statements correctly describes these movements?

A Electrons and negative ions both move towards the anode.

B Electrons and negative ions both move towards the cathode.

C Electrons move towards the anode and negative ions move towards the cathode.

D Electrons move towards the cathode and negative ions move towards the anode.

20. An unknown metal, M(s) and its aqueous salt, $M(NO_3)_2(aq)$ are combined with a silver half-cell in which the following reaction takes place:

$$Ag^+(aq) + e^- \rightarrow Ag(s) \quad [E°_{red} = +0.80\ V]$$

If $E°_{cell} = +1.36$ V, what is $E°_{red}$ for $M^{2+}(aq) + 2e^- \rightarrow M(s)$?

A +0.56 V **B** +0.24 V

C –0.24 V **D** –0.56 V

The Periodic Table of the Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										4 He helium 2
7 Li lithium 3	9 Be beryllium 4											11 B boron 5	12 C carbon 6	14 N nitrogen 7	16 O oxygen 8	19 F fluorine 9	20 Ne neon 10
23 Na sodium 11	24 Mg magnesium 12											27 Al aluminium 13	28 Si silicon 14	31 P phosphorus 15	32 S sulfur 16	35.5 Cl chlorine 17	40 Ar argon 18
39 K potassium 19	40 Ca calcium 20	45 Sc scandium 21	48 Ti titanium 22	51 V vanadium 23	52 Cr chromium 24	55 Mn manganese 25	56 Fe iron 26	59 Co cobalt 27	59 Ni nickel 28	64 Cu copper 29	65 Zn zinc 30	70 Ga gallium 31	73 Ge germanium 32	75 As arsenic 33	79 Se selenium 34	80 Br bromine 35	84 Kr krypton 36
85 Rb rubidium 37	88 Sr strontium 38	89 Y yttrium 39	91 Zr zirconium 40	93 Nb niobium 41	96 Mo molybdenum 42	– Tc technetium 43	101 Ru ruthenium 44	103 Rh rhodium 45	106 Pd palladium 46	108 Ag silver 47	112 Cd cadmium 48	115 In indium 49	119 Sn tin 50	122 Sb antimony 51	128 Te tellurium 52	127 I iodine 53	131 Xe xenon 54
133 Cs caesium 55	137 Ba barium 56	139 La lanthanum 57 *	178 Hf hafnium 72	181 Ta tantalum 73	184 W tungsten 74	186 Re rhenium 75	190 Os osmium 76	192 Ir iridium 77	195 Pt platinum 78	197 Au gold 79	201 Hg mercury 80	204 Tl thallium 81	207 Pb lead 82	209 Bi bismuth 83	– Po polonium 84	– At astatine 85	– Rn radon 86
– Fr francium 87	– Ra radium 88	– Ac actinium 89 †															

*58-71 Lanthanoid series

†90-103 Actinoid series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	– Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	162 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	– Pa protactinium 91	238 U uranium 92	– Np neptunium 93	– Pu plutonium 94	– Am americium 95	– Cm curium 96	– Bk berkelium 97	– Cf californium 98	– Es einsteinium 99	– Fm fermium 100	– Md mendelevium 101	– No nobelium 102	– Lr lawrencium 103

Key

a
X
b

a = relative atomic mass
X = atomic symbol
b = proton (atomic) number

Answers

1. **B**
2. **D**
3. **A**
4. **C**
5. **B**
6. **B**
7. **D**
8. **D**
9. **C**
10. **D**
11. **C**
12. **D**
13. **D**
14. **C**
15. **B**
16. **A**
17. **D**
18. **B**
19. **D**
20. **D**