

Name: (

Chem!stry class:

Date: / /

Chemistry Olympiad Training for Secondary School Level – Part Three

1.	Which one	of the follow	wing substand	ces has the	highest meltin	a point?
Ι.	which one	or the rollo	wing Substant	ces has the	nignest meitin	ia po

A Li₂O

MgO

C CO_2

D N_2O_5

Α NF_3 NCI₃

C NBr₃

 NI_3 D

Butan-1-ol

Ethanol

C Methanol 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.

$$C_2 H_2(g) \ + \ ^5/_2 O_2(g) \ \to \ 2 CO_2(g) \ + \ H_2 O(I) \\ \hspace{2cm} \Delta H^\circ = -1299.5$$

$$\Delta H^{\circ} = -1299.5$$

$$C(s) + O_2(g) \rightarrow CO_2(g)$$

$$\Delta H^{\circ} = -393.5$$

$$H_2(g) + {}^{1}/{}_{2}O_2(g) \rightarrow H_2O(I)$$

$$\Delta H^{\circ} = -285.8$$

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 $X + Y \rightarrow Z$ 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

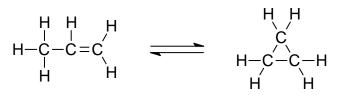
What is the rate law for this reaction?

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 CH₃CH=CH₂ 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** S²⁻

B K

C Sc²⁺

- D Ti⁴
- **10.** Which substance will form hydrogen bonds to water molecules but will not form hydrogen bonds with its own molecules?
 - A HF

B C₂H₅OH

C CH₃NH₂

D CH₃OCH₃

- **11.** What is the number of π -bonds in butenedioic acid, C₄H₄O₄?
 - **A** '

B 2

C 3

- **D** 4
- 12. In which list are the ions arranged in order of increasing size?
 - **A** $F^- < S^{2-} < Al^{3+} < Mg^{2+}$
 - $\textbf{B} \quad F^- < S^{2-} < Mg^{2+} < Al^{3+}$
 - **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?

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

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

A 5×10^{-6}

B 2×10^{-11}

 $C 1 \times 10^{-16}$

- **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 Energi	es / 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 C₆H₁₀ is least stable?

Α

В

H H H C C H H C C H

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:

С	Н	N	0
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 $C_{14}H_6N_6O_{12}$

 $\textbf{B} \quad C_{15}H_{10}N_6O_{11}$

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

- **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(NO₃)₂(aq) are combined with a silver half-cell in which the following reaction takes place:

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

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

The Periodic Table of the Elements

I	-		9						Gr	Group								
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Package Pack								hydrogen 1										helium 2
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Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I 38 40 41 43 44 45 46 47 48 49 50 51 52 53 138 178 181 184 186 190 192 195 197 204 207 209 - - Ba La Hf Ta W Re Os Ir Pt Au Hg Ti Pb Bismuth polonium satatine 56 57 72 73 76 77 78 79 80 81 Po At Ra Ac Ac Ac 77 78 79 80 81 9 9 9 Ra Ac Ac Ac Ac 89 8 8 8 8 8	8	88	89	91	93	96	1	101	103	106	108	112	1	119	122	128	127	131
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37 139 178 181 186 190 192 195 197 201 204 207 209 - </td <td>rubidium 3</td> <td>ontium</td> <td>yttrium 39</td> <td>zirconium 40</td> <td>obium</td> <td>molybdenu m</td> <td>technetium 43</td> <td>uthenium 4</td> <td>rhodium 45</td> <td>palladium 46</td> <td>silver 47</td> <td>cadmium 48</td> <td>indium 49</td> <td>tin 50</td> <td>antimony 51</td> <td>tellurium 52</td> <td>iodine 53</td> <td>xenon 54</td>	rubidium 3	ontium	yttrium 39	zirconium 40	obium	molybdenu m	technetium 43	uthenium 4	rhodium 45	palladium 46	silver 47	cadmium 48	indium 49	tin 50	antimony 51	tellurium 52	iodine 53	xenon 54
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Ra radium 88	60.	1	1															
radium 88	_	Ra	Ac															
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*58-71 Lanthanoid series †90-103 Actinoid series

	140	141	4	1	150	152	157	159	162	165	167	169	173	175
	Se	P	PN	Pm	Sm	Eu	PS	Tb	Dy	운	ш	Tm	Yb	Lu
	cerium 58	praseodymium 59	neodymium 60	promethium 61	samarium 62	europium 63	gadolinium 64	terbium 65	dysprosium 66	holmium 67	erbium 68	thulium 69	ytterbium 70	1
SS	232	1	238	1	1	1	1	1	1	1	1	1	1	1
	H	Pa	ח	ď	Pu	Am	Cm	BK	ŭ	Es	Fm	Md	No	ב
mbor	thorium	protactinium	uranium	neptunium	plutonium	americium	curium	berkelium	californium	ein	fermium	mendelevium		lawrencium
100	06	91	92	93	8	95	96	97	98	66	100	101		103

6

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