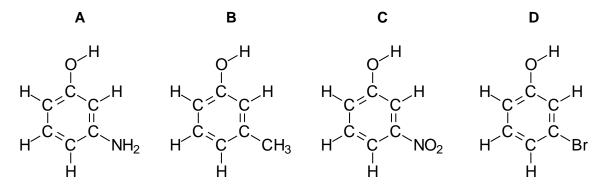
NANYANC			Name: (	)
Contraction of the second	a popolo	Chem!stry	Class:	
· · · · · · · · · · · · · · · · · · ·	and the second		Date: / /	

## Chemistry Olympiad Training for Secondary School Level - Part Five

- 1. Which one of the following series of ions is arranged in order of increasing ionic radius?
  - $\textbf{A} \quad Mg^{2+} < S^{2-} < Cl^- < K^+ < Ca^{2+}$
  - ${\bm B} ~~Mg^{2+} < Ca^{2+} < K^+ < Cl^- < S^{2-}$
  - $\label{eq:constraint} \bm{C} ~~ S^{2-} < C I^- < K^+ < M g^{2+} < C a^{2+}$
  - $\mathbf{D} \quad S^{2-} < Mg^{2+} < Ca^{2+} < Cl^{-} < K^{+}$
- 2. Which one of the following compounds could **not** be obtained by oxidising phosphorus trifluoride, PF<sub>3</sub>?

Α	$Na_4P_2O_7 \cdot 10H_2O$	В	$H_4P_2O_6$
С	(NH <sub>4</sub> ) <sub>2</sub> HPO <sub>3</sub> ·H <sub>2</sub> O	D	Ca <sub>5</sub> (PO <sub>4</sub> ) <sub>3</sub> F

3. Ethanoic acid was heated with an unknown compound X and a catalytic amount of sulfuric acid. The reaction mixture was shown by mass spectrometry to contain a compound of molar mass 193 g mol<sup>-1</sup>. Which one of the following could be compound X?



- 4. Equal masses of each of the following compounds were treated with excess hydrochloric acid. Which one produced the greatest volume of carbon dioxide?
  - A Sodium carbonate
  - **B** Magnesium carbonate
  - **C** Potassium carbonate
  - D Calcium carbonate

5. What is the enthalpy change for the complete combustion of one mole of liquid isopropanol (molecular formula C<sub>3</sub>H<sub>8</sub>O)?

	$3 C(s) + 4 H_2(g) + \frac{1}{2} O_2(g)$	$\rightarrow C_3H_8O$	(I)	$\Delta H_{\rm f} = -318 \text{ kJ mol}^{-1}$
	$C(s) + O_2(g) \rightarrow C c$	O <sub>2</sub> (g)		$\Delta H_{\rm f} = -394 \text{ kJ mol}^{-1}$
	$H_2(g) + {}^{1\!/_2}O_2(g) \rightarrow$	H <sub>2</sub> O(I)		$\Delta H_{\rm f} = -286 \text{ kJ mol}^{-1}$
Α	–362 kJ	В -	-998 kJ	
С	–2008 kJ	D -	-2116 kJ	

6. Sodium metal is produced industrially by the electrolysis of molten NaCl, while steel is produced by CO reduction of ores containing Fe(III) in a blast furnace. Tantalum is another useful metal, often used surgically to repair bone because of its high resistance to corrosion. Which one of the following methods could be used industrially to produce tantalum from naturally occurring Ta(V) ores?

Na⁺(aq) + <i>e</i> ⁻ ⇄ Na(s)	$E^{\circ} = -2.71 \text{ V}$
$Fe^{3+}(aq) + 3e^{-} \rightleftharpoons Fe(s)$	$E^{\circ} = +0.82 \text{ V}$
$Ta_2O_5(s) + 10 H^+(aq) + 10 e^- \rightleftharpoons 2 Ta(s) + 5 H_2O(l)$	$E^{\circ} = -0.75 \text{ V}$
$CO_2(g) + 2 H^+(aq) + 2 e^- \rightleftharpoons CO(g) + H_2O(I)$	$E^{\circ} = -0.10 \text{ V}$

- A Either reduction with sodium metal or reduction in a blast furnace.
- **B** Either electrolysis or reduction with sodium metal.
- **C** Electrolysis only.
- **D** Reduction in a blast furnace only.
- 7. What is the oxidation state of molybdenum in the ion  $[Mn_2O_4(NCS)_6]^{4-2}$ ?

Α	+3	В	+4
С	+5	С	+6

- **8.** Which of the following groups of ions can co-exist in significant quantities in aqueous solution without reacting with each other?
  - A Na<sup>+</sup>, Cl<sup>-</sup>, K<sup>+</sup>, OH<sup>-</sup>
  - $\textbf{B} \quad Ag^{+}, NO_{3}^{-}, Na^{+}, Cl^{-}$
  - $\pmb{C} \quad Cu^{2+},\,SO_4{}^{2-},\,Zn^{2+},\,OH^-$
  - **D** Pb<sup>2+</sup>, NO<sub>3</sub><sup>-</sup>, K<sup>+</sup>, I<sup>-</sup>

9. The following is a list of selected standard reduction potentials:

$Cd^{2+}(aq) + 2 e^{-} \rightarrow Cd(s)$	$E^\circ = -0.40 \text{ V}$
$Zn^{2+}(aq) + 2 e^{-} \rightarrow Zn(s)$	$E^\circ = -0.76 \text{ V}$
Ni <sup>2+</sup> (aq) + 2 $e^- \rightarrow$ Ni(s)	$E^{\circ} = -0.23 \text{ V}$

By referring to the standard reduction potentials above, which one of the following species is the best oxidising agent?

- A
   Cd(s)
   B
   Zn<sup>2+</sup>(aq)

   C
   Ni<sup>2+</sup>(aq)
   D
   Zn(s)
- **10.** It is known that carbon monoxide reacts exothermically with hydrogen gas to form methanol at 400°C, in the presence of a catalyst:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) + heat$$

A mixture of carbon monoxide, hydrogen gas and methanol placed under conditions described above achieves equilibrium in a closed container. If the reaction temperature is changed to 450°C, which of the following statements is correct?

- A The total number of molecules in the container decreases.
- **B** The reaction rates of both the forward and reverse reactions remains constant.
- **C** The average molecular mass of the gaseous mixture decreases.
- **D** The total pressure within the container decreases.
- **11.** A gaseous mixture containing ethane and methane underwent complete combustion to produce 5.28 g of carbon dioxide and 3.78 g of water. What is the volume ratio of ethane to methane in the original mixture?
  - A
     1:1
     B
     1:2

     C
     2:1
     D
     1:4
- 12. Given the following table of electronegativities, which one of the following bonds is most polar?

	Element	Р	С	S	Ν	CI
	Electronegativity	2.19	2.55	2.58	3.04	3.16
A	P–S		<b>B</b> S-N			
	S–Cl		<b>D</b> C–C			

- **13.** The enthalpy change of which reaction corresponds to  $\Delta H^{\circ}_{f}$  for Na<sub>2</sub>CO<sub>3</sub>(s) at 298 K?

  - **B** Na<sub>2</sub>O(s) + CO<sub>2</sub>(g)  $\rightarrow$  Na<sub>2</sub>CO<sub>3</sub>(s)
  - **C** 2 Na<sup>+</sup>(aq) + CO<sub>3</sub><sup>2–</sup>(aq)  $\rightarrow$  Na<sub>2</sub>CO<sub>3</sub>(s)
  - **D** 2 Na<sup>+</sup>(aq) + 2 OH<sup>-</sup>(aq) + CO<sub>2</sub>(g)  $\rightarrow$  Na<sub>2</sub>CO<sub>3</sub>(s) + H<sub>2</sub>O(l)
- **14.** A sample of oxygen gas and a sample of an unknown gas are weighed separately in the same evacuated flask. Use the data given to find the molar mass of the unknown gas. Assume that all experiments are conducted at the same temperature and pressure.

mass of evacuated flask	124.46 g
mass of flask + oxygen	125.10 g
mass of flask + unknown gas	125.34 g

Α	22 g mol <sup>-1</sup>	В	38 g mol <sup>-1</sup>
С	44 g mol <sup>−1</sup>	D	84 g mol <sup>-1</sup>

- 15. What is the most effective way to condense a gas?
  - A Decrease the temperature and increase the pressure.
  - **B** Decrease the temperature and decrease the pressure.
  - **C** Increase the temperature and decrease the pressure.
  - **D** Increase the temperature and increase the pressure.
- **16.** For a rate law of the form:

rate = 
$$k \times [A]^m \times [B]^n$$

the exponents m and n are obtained from:

- A Changes in the rate of reaction with changing temperature.
- **B** The coefficients of A and B in the balanced chemical equation.
- **C** The concentrations of A and B in a single experiment.
- **D** Changes in the rate of reaction for different concentrations of A and B.
- 17. Which reaction occurs with the greatest increase in entropy?

$$\mathbf{A} \quad 2 \ \mathsf{H}_2\mathsf{O}(\mathsf{I}) \ \rightarrow \ 2 \ \mathsf{H}_2(\mathsf{g}) \ \rightarrow \ \mathsf{O}_2(\mathsf{g})$$

- $\mathbf{B} \quad 2 \text{ NO}(g) \rightarrow \text{ N}_2(g) + \text{ O}_2(g)$
- $\label{eq:constraint} \begin{array}{ccc} C(s) \ + \ O_2(g) \ \rightarrow \ CO_2(g) \end{array}$
- $\label{eq:def_def_def} \begin{array}{rcl} \textbf{D} & H_2(g) \ + \ Cl_2(g) \ \rightarrow \ 2 \ HCl(g) \end{array}$

18. The rates of which reactions are increased when temperature is increased?

I exothermic	
II endothermic	

- A I only. B II only.
- C Both I and II. D Neither I nor II.
- **19.** The boiling points of the halogens, F<sub>2</sub>, Cl<sub>2</sub>, Br<sub>2</sub> and I<sub>2</sub>, increase in that order. This is best attributed to differences in:
  - A Covalent bond strengths.
  - **B** Dipole forces.
  - **C** van der Waals forces.
  - D Hydrogen bonds.
- 20. Which statement is true for a reaction at equilibrium?
  - A All reactions cease.
  - **B** The reaction has reached completion.
  - **C** The rates of the forward and reverse reactions are equal.
  - **D** The amount of product equals the amount of reactant.

The Periodic Table of the Elements

								Gn	Group								
	I											III	N	Λ	N	NI	0
							← I										4 He
							hydrogen 1										helium 2
7	6	[										11	12	14	16	19	20
<b>C</b>	Be											В	U	z	0	ш	Ne
lithium 3	beryllium 4											5 boron	carbon 6	nitrogen 7	oxygen 8	fluorine 9	10
23	24	T										27	28	31	32	35.5	40
Na	Mg											AI	Si	Р			Ar
sodium 11	magnesium 12	F										aluminium 13	silicon 14	phosphorus 15	sulfur 16	chlorine 17	argon 18
39	40	45	48	51	52	55	56	59	59	29	65	20	73	75			84
¥			F	>		Mn	Fe	ပိ	ïz	Cu	Zn		Ge		Se	Br	Kr
potassium	calcium	scandium	titanium	muipeux		chromium manganese	90	cobalt	nickel	copper	zinc	gallium	germanium	arsenic	selenium	bromine	krypton
10	70 VU	00	77	52	74	07	107	1001	207	200	20		25	3	5	201	201
22	8 6	80 >	19	SUP NIP	06 06	I F		103	001	20L	711	CLL	ALL S	122	128	121	131
	ō	1	7		DIVI O		_	Ē		DY.	3	H	5	00	D -	1	PC
37	strontium 38	39	Zirconium 40	41	molybdenu m 47	technetium 43	44	45	palladium 46	silver 47	cadmium 48	49	50 tin	antimony 51	tellunum 52	53	54 xenon
133	137	139	178	181	184	186	190	192	195	197	201	204	207	209	1	1	1
Cs	Ba	La	Ŧ	Ta	M	Re	Os	Ir		Au	Ρđ	Τl	Pb	Bi	Po	At	Rn
caesium 55	barium 56	57 * 7	hafnium 72	tantalum 73	tungsten 74	rhenium 75	osmium 76	iridium 77	platinum 78	79 79	mercury 80	thallium 81	lead 82	bismuth 83	polonium 84	astatine 85	radon 86
1	1	1			Ċ,			2			C.			e,			1
Ŀ	Ra	Ac															
francium 87	88	actinium 89 †															
*58-71 L	anthano	*58-71 Lanthanoid series															
+90-103	†90-103 Actinoid series	l series															
			8	140	141	144	1	150	152	157	159	162	165	167	169	173	175
				Ce	Å.	PN	Pm			Gd	Tb	D	P	ш		Υb	Lu
				cerium 58	59	60	59 60 61 61	samarium 62	europium 63	gadolinium 64	terbium 65	dysprosium 66	holmium 67	erbium 68	thulium 69	ytterbium 70	Iutetium 71
Key a		a = relative atomic mass	mass	232	1	238	1		1	I	1	1		1	1	1	I
×		X = atomic symbol	160	Ъ	Ра		dN	Pu		Ca	BK	പ്	Es		pW	No	
	ot:	b = proton (atomic) number		thorium	protactinium 01	0.0	neptunium	plutonium	americium	curium	berkelium 07	californium	californium einsteinium	100	mendelevium	nobelium 100	lawrencium 102
2	1		1	De	10	26	22	5		00	10	20	22	001	101	102	201

## Answers

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