CHEMISTRY
Higher Level
Paper 1
Preliminary Examinations

Tuesday 29 August 2023

1 hour

INSTRUCTIONS TO CANDIDATES

- Write your name, class and index number in the blanks below.
- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- The periodic table is provided for reference on page 2 of this examination paper.
- The maximum mark for this examination paper is **[40 marks]**.

Name: _____

Class: _____

Index: _____

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The periodic table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 **H** 1.01						Atomic number **Element** Relative atomic mass											2 **He** 4.00
2	3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
3	11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
4	19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.63	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.90
5	37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.96	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
6	55 **Cs** 132.91	56 **Ba** 137.33	57 † **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.20	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** (226)	89 ‡ **Ac** (227)	104 **Rf** (267)	105 **Db** (268)	106 **Sg** (269)	107 **Bh** (270)	108 **Hs** (269)	109 **Mt** (278)	110 **Ds** (281)	111 **Rg** (281)	112 **Cn** (285)	113 **Uut** (286)	114 **Uuq** (289)	115 **Uup** (288)	116 **Uuh** (293)	117 **Uus** (294)	118 **Uuo** (294)

†	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
‡	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

1. What is the sum of coefficients when the following equation is balanced using the smallest whole number?

$$\ldots.Fe^{2+} + \ldots.Cr_2O_7^{2-} + \ldots.H^+ \rightarrow \ldots.Fe^{3+} + \ldots.Cr^{3+} + \ldots.H_2O$$

A. 26

B. 28

C. 31

D. 36

2. What is the final concentration, in mol dm^{-3}, of hydrochloric acid when 200 cm^3 of 0.100 mol dm^{-3} hydrochloric acid is mixed with 300 cm^3 0.200 mol dm^{-3} hydrochloric acid?

A. 0.140

B. 0.150

C. 0.160

D. 0.190

3. 2.00 g of an alcohol, when vaporized, has a volume of 426 cm^3 at 400 K and 100 kPa. Which equation shows its molar mass in g mol^{-1}?

A. $\dfrac{2.00 \times 8.31 \times 400}{100 \times 426}$

B. $\dfrac{2.00 \times 8.31 \times 400 \times 10^6}{100 \times 426}$

C. $\dfrac{2.00 \times 8.31 \times 400}{10^6 \times 426 \times 100}$

D. $\dfrac{2.00 \times 8.31 \times 400 \times 10^6}{100 \times 10^3 \times 426}$

4. Which of these statements **cannot** be deduced from the periodic table on page 2?

A. Each chromium atom has 28 neutrons.

B. There are a few isotopes of neon in nature.

C. There are 15 lanthanoids and 15 actinoids.

D. The oxides of chlorine are acidic.

5. The first six ionization energies, in kJ mol^{-1}, of an element are given below.

IE_1	IE_2	IE_3	IE_4	IE_5	IE_6
578	1816	2744	11 576	14 829	18 375

Which group in the periodic table is this element found?

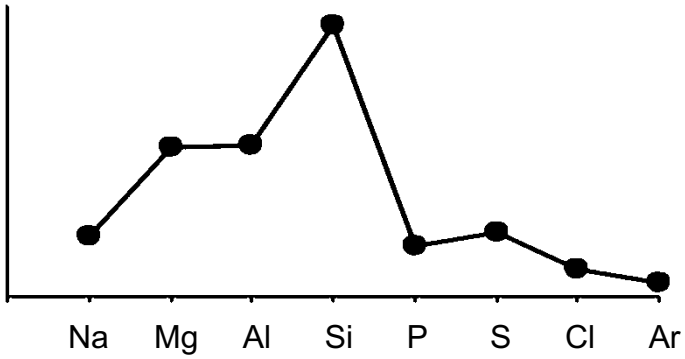
A. Group 2

B. Group 13

C. Group 15

D. Group 16

6. The graph shows a set of data for the elements in period 3.



What is the label on the vertical axis of this graph?

A. First ionization energy

B. Electrical conductivity

C. Electronegativity

D. Melting point

7. Which oxide does **not** dissolve in water but reacts with an alkali?

A. MgO

B. SiO_2

C. P_4O_{10}

D. SO_3

8. What is the overall charge, *x*, of this iron(III) complex?

$$[Fe(H_2O)_4(OH)_2]^x$$

A. 3+

B. 1+

C. 1-

D. 2-

9. Which combination leads to a strong metallic bond?

	Charge on the metal ion	**Radius of ion**
A.	high	large
B.	high	small
C.	low	small
D.	low	large

10. Which series shows molecules in order of increasing bond angles?

A. $NH_3 < CH_4 < CO_2$

B. $NH_3 < CH_4 < H_2O$

C. $CH_4 < BF_3 < NH_3$

D. $H_2O < CO_2 < BF_3$

11. Diamond, graphite and buckminsterfullerene are three allotropes of carbon. Which statement is correct for all three allotropes?

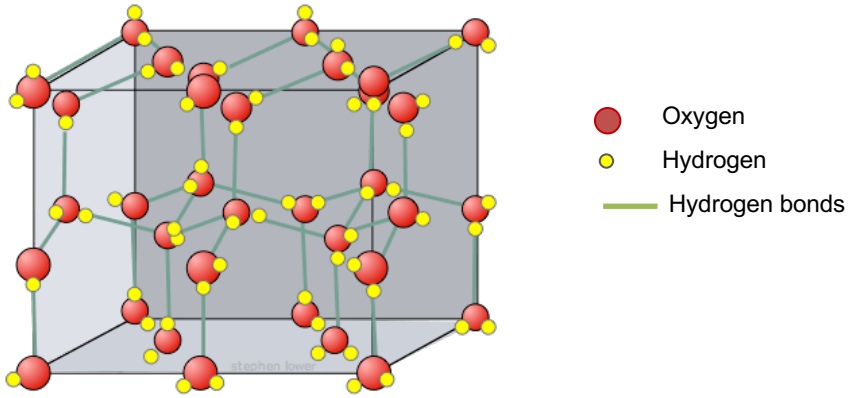
A. σ bonds are present in all of them.

B. Bond angles of 120° are present in all of them.

C. Delocalized electrons are present in all of them.

D. All of them have giant covalent lattice structures.

12. The diagram shows the structure of ice.



[Source: https://johncarlosbaez.wordpress.com/2012/04/15/ice/]

Which statement is correct?

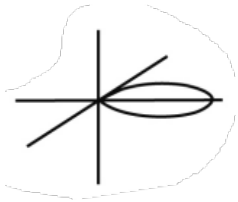
A. Two electron pairs from each oxygen atom are involved in forming hydrogen bonds.

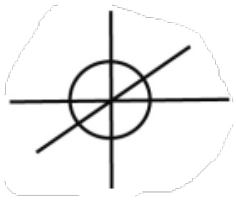
B. London (dispersion) forces and dipole-dipole forces are absent in ice.

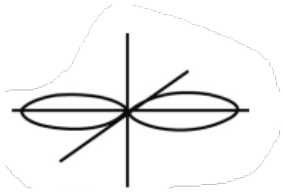
C. All bond angles surrounding each oxygen atom is 120°.

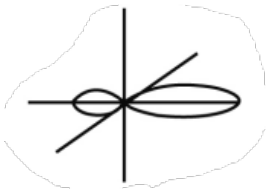
D. The structure makes ice denser than water.

13. Which diagram represents the shape of a *sp* hybridized orbital?

A. 

B. 

C. 

D. 

14. Which processes are exothermic?

I. Freezing
II. Melting
III. Condensation

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

15. Which equation represents the average bond enthalpy of a O–H bond?

A. $\frac{1}{2}H_2O\,(g) \rightarrow H\,(g) + \frac{1}{2}O\,(g)$

B. $H_2O\,(g) \rightarrow H_2\,(g) + \frac{1}{2}O_2\,(g)$

C. $H_2\,(g) + \frac{1}{2}O_2\,(g) \rightarrow H_2O\,(l)$

D. $2H\,(g) + \frac{1}{2}O_2\,(g) \rightarrow H_2O\,(l)$

16. Consider the following enthalpy of combustion data.

$C\ (s) + O_2\ (g) \rightarrow CO_2\ (g)$ $\Delta H = x$ kJ mol^{-1}

$H_2\ (g) + \frac{1}{2}O_2\ (g) \rightarrow H_2O\ (l)$ $\Delta H = y$ kJ mol^{-1}

$C_2H_6\ (g) + \frac{7}{2}O_2\ (g) \rightarrow 2CO_2\ (g) + 3H_2O\ (l)$ $\Delta H = z$ kJ mol^{-1}

What is the enthalpy of formation of ethane in kJ mol^{-1}?

$2C\ (s) + 3H_2\ (g) \rightarrow C_2H_6\ (g)$

A. $x + y - z$

B. $z - x - y$

C. $z - 2x - 3y$

D. $2x + 3y - z$

17. Which reaction shows the largest increase in entropy?

A. $2KOH\ (aq) + FeSO_4\ (aq) \rightarrow K_2SO_4\ (aq) + Fe(OH)_2\ (s)$

B. $C_2H_4\ (g) + 3O_2\ (g) \rightarrow 2CO_2\ (g) + 2H_2O\ (g)$

C. $MgSO_3\ (s) \rightarrow MgO\ (s) + SO_2\ (g)$

D. $(NH_4)_2Cr_2O_7\ (s) \rightarrow Cr_2O_3\ (s) + N_2\ (g) + 4H_2O\ (g)$

18. Which statements describe the effects of adding a catalyst and increasing the temperature on the rate of a reaction?

	Adding a catalyst	**Increasing the temperature**
A.	collision frequency increases	collision frequency increases
B.	activation energy decreases	collision frequency increases
C.	collision frequency increases	activation energy increases
D.	activation energy increases	activation energy decreases

19. The rate expression for the reaction P + Q → R + S is rate = k[Q] .

Which statement is correct for the reaction?

A. Q is a catalyst in this reaction.

B. The concentration of P does not change during the reaction.

C. The rate of reaction is not affected by the concentration of P.

D. The concentration of Q decreases linearly as the reaction progresses.

20. Consider the following reaction.

$$NO_2(g) + CO(g) \rightarrow NO(g) + CO_2(g)$$

At T < 227 °C, the rate expression is rate = k $[NO_2]^2$. Which of these mechanisms is consistent with the rate expression?

A. $NO_2 + NO_2 \rightleftharpoons N_2O_4$ fast
$N_2O_4 + 2CO \rightarrow 2NO + 2CO_2$ slow

B. $NO_2 + CO \rightarrow NO + CO_2$ slow

C. $NO_2 \rightarrow NO + O$ slow
$CO + O \rightarrow CO_2$ fast

D. $NO_2 + NO_2 \rightarrow NO_3 + NO$ slow
$NO_3 + CO \rightarrow NO_2 + CO_2$ fast

21. The exothermic reaction $I_2(g) + 3Cl_2(g) \rightleftharpoons 2ICl_3(g)$ is at equilibrium. Which is correct of the equilibrium constant, K_c, and the position of the equilibrium when temperature is raised at constant volume?

	Equilibrium constant, K_c	**Position of equilibrium**
A.	decrease	shift towards products
B.	decrease	shift towards reactants
C.	increase	shift towards products
D.	increase	shift towards reactants

22. The equilibrium constant for $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ is *K*. What is the equilibrium constant for this equation $4NH_3(g) \rightleftharpoons 2N_2(g) + 6H_2(g)$?

A. $\frac{1}{K}$

B. $\frac{1}{2K}$

C. $\frac{1}{K^2}$

D. $\frac{1}{2K^2}$

23. Which of the following would shift the equilibrium to the right?

$$[Cu(H_2O)_6]^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons [CuCl_4]^{2-}(aq) + 6H_2O(l) \qquad \Delta H > 0$$

I. Increasing the temperature of the solution

II. Adding concentrated HCl

III. Removing water by evaporation

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

24. Equal volumes of 0.10 mol dm^{-3} butanoic acid and hydrochloric acid were titrated with 0.10 mol dm^{-3} sodium hydroxide solution. Which of the following is the same for both titrations?

A. Initial pH

B. Initial electrical conductivity

C. Volume of NaOH for complete neutralization

D. Heat evolved in the neutralization

25. Which substance would form the strongest conjugate base?

A. CH_3COOH

B. HCl

C. H_2O

D. H_2SO_4

26. What is the order of increasing pH of these bases with the same concentration?

Base	**pK_b**
$C_6H_5NH_2$	9.13
$(CH_3)_2NH$	3.27
NH_3	4.75

A. $NH_3 < (CH_3)_2NH < C_6H_5NH_2$

B. $C_6H_5NH_2 < (CH_3)_2NH < NH_3$

C. $(CH_3)_2NH < NH_3 < C_6H_5NH_2$

D. $C_6H_5NH_2 < NH_3 < (CH_3)_2NH$

27. A solution HX has pH = 2 and a solution HY has pH = 3. Which statement is correct?

A. HX is a stronger acid than HY.

B. HY is a stronger acid than HX.

C. The concentration of H^+ in HX is $\frac{3}{2}$ times greater than the concentration of H^+ in HY.

D. The concentration of H^+ in HX is 10 times greater than the concentration of H^+ in HY.

28. Disproportionation reaction is a redox reaction in which the same substance is both reduced and oxidized. Which reaction is **not** a disproportionation reaction?

A. $4H^+ + 3MnO_4^{2-} \rightarrow MnO_2 + 2MnO_4^- + 2H_2O$

B. $2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$

C. $MgSO_3 + H_2SO_4 \rightarrow MgSO_4 + SO_2 + H_2O$

D. $Cu_2O + H_2SO_4 \rightarrow Cu + CuSO_4 + H_2O$

29. The cell notation of a voltaic cell is as shown.

$$Mg(s) \mid Mg^{2+}(aq) \parallel Fe^{3+}(aq), Fe^{2+}(aq) \mid Pt(s)$$

Which statement is correct?

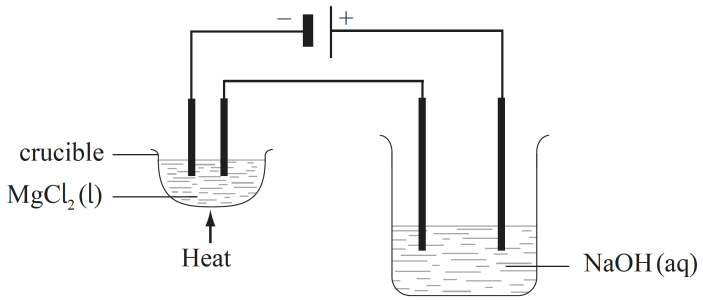
A. Mg^{2+} | Mg half-cell is the positive terminal of the cell.

B. Electrons flow from Mg electrode to Pt electrode.

C. Oxidation occurs in the Fe^{3+} | Fe^{2+} half-cell.

D. The Mg^{2+} | Mg half-cell is the cathode of the voltaic cell.

30. The same amount of current is passed through both electrolytic cells as shown. Graphite electrodes are used in both electrolytic cells.



[Source: International Baccalaureate Organization]

Which observation can be made from this set-up?

A. The volume ratio of gases collected at both cathodes is 1:1.

B. The volume ratio of gases collected at both anodes is 1:1.

C. The pH of the NaOH (aq) electrolyte will decrease.

D. Electron flows from the $MgCl_2$ (l) cell to the NaOH (aq) cell.

31. Which statement is correct using this data?

Zn^{2+} (aq) + $2e^-$ ⇌ Zn (s)	$E^{\ominus}$ = – 0.76 V
Cr^{3+} (aq) + e^- ⇌ Cr^{2+} (aq)	$E^{\ominus}$ = – 0.41 V
Sn^{2+} (aq) + $2e^-$ ⇌ Sn (s)	$E^{\ominus}$ = – 0.14 V
Sn^{4+} (aq) + $2e^-$ ⇌ Sn^{2+} (aq)	$E^{\ominus}$ = + 0.15 V

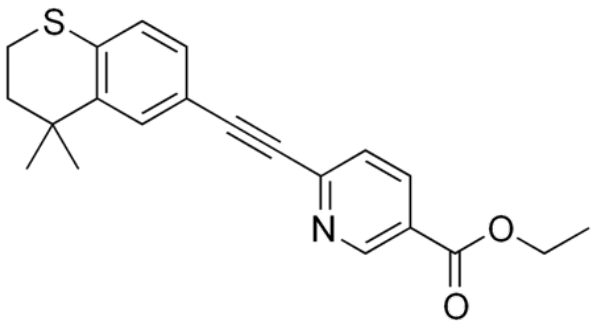
A. Zn is a stronger reducing agent than Sn^{2+}.

B. Cr^{2+} can reduce Zn^{2+}.

C. Cr^{3+} can oxidize Sn^{2+}.

D. Sn^{2+} is a stronger oxidizing agent than Sn^{4+}.

32. What is the index of hydrogen deficiency (IHD) of this molecule?



A. 8

B. 9

C. 12

D. 14

33. Which pairs of molecules are isomers?

I. $HCCCH_3$ and H_2CCHCH_3

II. $HOCH_2CH_2CH_3$ and $CH_3CH(OH)CH_3$

III. $HCOOCH_2CH_3$ and CH_3COOCH_3

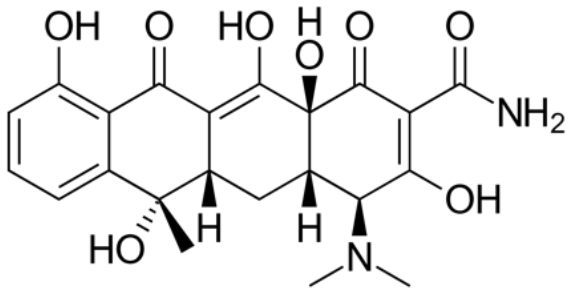
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

34. Which functional groups are present in this compound?



A. Amine, carbonyl, carboxamide

B. Amine, ester, hydroxyl

C. Amine, carboxyl, carboxamide

D. Alkenyl, ester, hydroxyl

35. When 2-bromobutane reacts with sodium hydroxide, approximately 75% of the product molecules show inversion of configuration. Which statement best explains this observation?

A. The rate determining step is unimolecular.

B. The rate determining step is bimolecular.

C. The reaction undergoes both S_N1 and S_N2 mechanisms.

D. 2-bromobutane is a chiral molecule.

36. What is the product of the reduction of 2-methylbutanoic acid by lithium aluminium hydride?

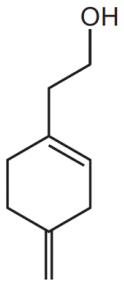
A. 2-methylbutane

B. 2-methylbutan-1-ol

C. 2-methylbut-1-ene

D. 2-methylbutanal

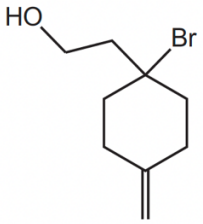
37. Excess dry hydrogen bromide is warmed with compound **Y**.



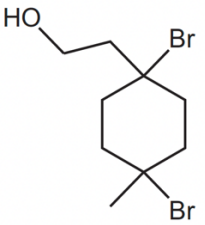
Compound **Y**

What is the major product of this reaction?

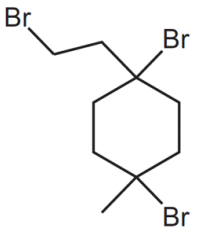
A.



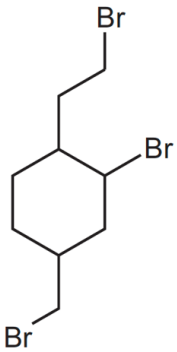
B.



C.



D.



38. Which molecule is optically inactive?

A. 1-bromo-2-chloroethane

B. 2-bromobutane

C. 3-bromobut-1-yne

D. 2-hydroxypropanoic acid

39. Which molecule shows configurational isomerism?

A. CH_2BrCH_2Cl

B. $CHBr=CCl_2$

C. CHBr=CHCl

D. 

40. A student obtained the following data to calculate q, using $q = mc\Delta T$.

m = 20.0 g ± 0.2 g

ΔT = 20 ℃ ± 2 ℃

c = 4.18 J $g^{-1}K^{-1}$

What is the percentage uncertainty in the calculated value of q?

A. 0.2

B. 2.2

C. 11

D. 20

-End of Paper-