88136101

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CHEMISTRY
HIGHER LEVEL
PAPER 1

Monday 18 November 2013 (afternoon)

1 hour

INSTRUCTIONS TO CANDIDATES

- 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]*.

8813-6101

The Periodic Table

1	**2**											**3**	**4**	**5**	**6**	**7**	**0**
1 **H** 1.01				Atomic number **Element** Relative atomic mass													2 **He** 4.00
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
11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.90	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.71	29 **Cu** 63.55	30 **Zn** 65.37	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** 98.91	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.40	49 **In** 114.82	50 **Sn** 118.69	51 **Sb** 121.75	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.30
55 **Cs** 132.91	56 **Ba** 137.34	57 † **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.85	75 **Re** 186.21	76 **Os** 190.21	77 **Ir** 192.22	78 **Pt** 195.09	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.37	82 **Pb** 207.19	83 **Bi** 208.98	84 **Po** (210)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 ‡ **Ac** (227)															
		†	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** 146.92	62 **Sm** 150.35	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.92	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97	
		‡	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (242)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (254)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)	

1. What is the total number of oxygen atoms in 0.200 mol of glucose, $C_6H_{12}O_6$?

A. 1.20

B. 6.00

C. 1.20×10^{23}

D. 7.22×10^{23}

2. What are the coefficients of $H_2SO_4(aq)$ and $H_3PO_4(aq)$ when the following equation is balanced using the smallest possible whole numbers?

$$\_\_\_ Ca_3(PO_4)_2(s) + \_\_\_ H_2SO_4(aq) \rightarrow \_\_\_ CaSO_4(s) + \_\_\_ H_3PO_4(aq)$$

	Coefficient of $H_2SO_4(aq)$	**Coefficient of $H_3PO_4(aq)$**
A.	1	2
B.	2	3
C.	3	1
D.	3	2

3. 7.102 g of Na_2SO_4 ($M = 142.04\ g\ mol^{-1}$) is dissolved in water to prepare $0.5000\ dm^3$ of solution. What is the concentration of Na_2SO_4 in $mol\ dm^{-3}$?

A. 2.500×10^{-2}

B. 1.000×10^{-1}

C. 1.000×10

D. 1.000×10^{2}

4. What are the numbers of neutrons and electrons in the iodine ion, $^{125}I^{+}$?

	Neutrons	**Electrons**
A.	53	53
B.	72	52
C.	72	53
D.	125	52

5. What is the abbreviated electron configuration of the telluride ion, Te^{2-}?

A. $[Kr]5s^2 5d^{10} 5p^6$

B. $[Kr]5s^2 4d^{10} 5p^2$

C. $[Kr]5s^2 4d^{10} 5p^4$

D. $[Kr]5s^2 4d^{10} 5p^6$

6. Which series is arranged in order of **increasing** radius?

A. $F < Cl^- < Cl$

B. $Rb < K < Na$

C. $Al^{3+} < Mg^{2+} < Na^+$

D. $I^- < Br^- < Cl^-$

7. Which oxides form acidic solutions when added to water?

A. $P_4O_{10}(s)$ and $SO_3(g)$

B. $Na_2O(s)$ and $MgO(s)$

C. $Al_2O_3(s)$ and $SiO_2(s)$

D. $MgO(s)$ and $Al_2O_3(s)$

8. Which compound is likely to be colourless?

A. $[Zn(H_2O)_6]Cl_2$

B. $[NH_4]_2[Fe(H_2O)_6][SO_4]_2$

C. $K_3[Co(CN)_6]$

D. $[Ni(NH_3)_6][BF_4]_2$

9. What is the formula of calcium nitride?

A. Ca_3N_2

B. Ca_2N_3

C. $Ca(NO_2)_2$

D. $Ca(NO_3)_2$

10. Which compounds have an ionic lattice structure in the solid state?

I. Silicon dioxide

II. Sodium fluoride

III. Ammonium nitrate

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

11. Which intermolecular forces exist between the following molecules?

	H_2Se	CO	H_2
A.	van der Waals' and dipole-dipole	van der Waals' and dipole-dipole	van der Waals' only
B.	van der Waals', dipole-dipole and hydrogen bonding	van der Waals' only	van der Waals' and hydrogen bonding
C.	van der Waals', dipole-dipole and hydrogen bonding	van der Waals' and dipole-dipole	van der Waals' only
D.	van der Waals' and dipole-dipole	van der Waals' and dipole-dipole	van der Waals' and hydrogen bonding

12. Which species have dative covalent bonding?

I. $[Fe(H_2O)_6]Cl_3$

II. NH_4^+

III. H_2O

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

13. How many sigma (σ) and pi (π) bonds are there in $CH_3CH_2CCCH_2COOH$?

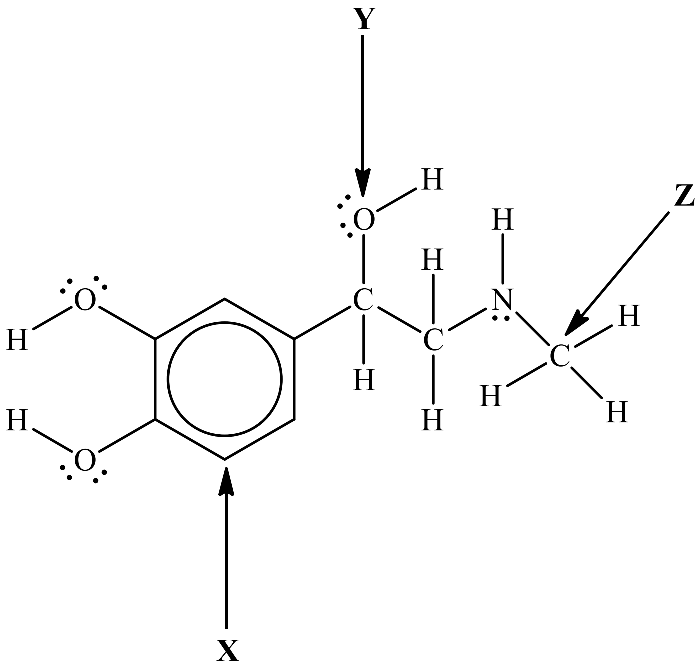
A. 13σ and 5π

B. 15σ and 2π

C. 15σ and 3π

D. 15σ only

14. What is the hybridization of atoms **X**, **Y** and **Z** in epinephrine?



	X	Y	Z
A.	sp^2	sp^3	sp^3
B.	sp^2	sp	sp^3
C.	sp^3	sp^2	sp^2
D.	sp^3	sp^3	sp^3

15. Which processes are exothermic?

I. $CH_3CH_2CH_3(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$

II. $Cl_2(g) \rightarrow 2Cl(g)$

III. $CH_3CH_2COOH(aq) + NaOH(aq) \rightarrow CH_3CH_2COONa(aq) + H_2O(l)$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

16. Consider the following two equations.

$$2Ca(s) + O_2(g) \rightarrow 2CaO(s) \qquad \Delta H^{\ominus} = +x \text{ kJ}$$

$$Ca(s) + 0.5O_2(g) + CO_2(g) \rightarrow CaCO_3(s) \qquad \Delta H^{\ominus} = +y \text{ kJ}$$

What is $\Delta H^{\ominus}$, in kJ, for the following reaction?

$$CaO(s) + CO_2(g) \rightarrow CaCO_3(s)$$

A. $y - 0.5x$

B. $y - x$

C. $0.5 - y$

D. $x - y$

17. Which ionic compound has the most endothermic lattice enthalpy?

A. Sodium chloride

B. Sodium oxide

C. Magnesium chloride

D. Magnesium oxide

18. Which processes are predicted to have a positive entropy change, ΔS?

I. $I_2(g) \rightarrow I_2(s)$

II. $4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$

III. $CH_3OH(l) \rightarrow CH_3OH(g)$

A. I and II only

B. I and III only

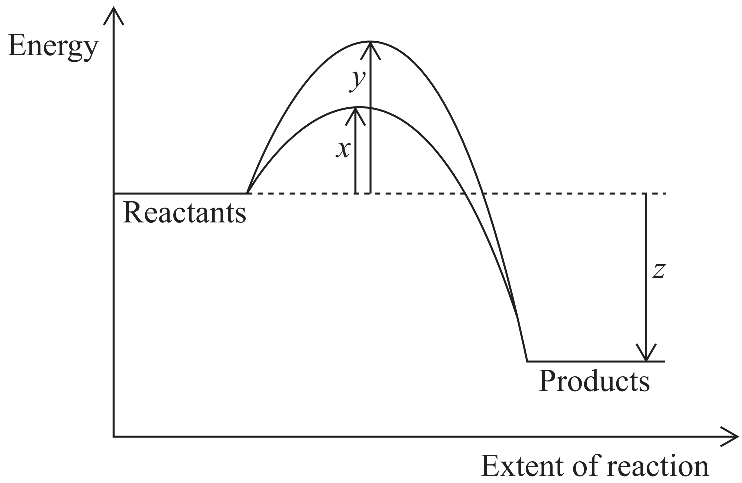
C. II and III only

D. I, II and III

19. Which combination of ΔH and ΔS signs will always result in a spontaneous reaction at all temperatures?

	ΔH	ΔS
A.	+	+
B.	+	–
C.	–	–
D.	–	+

20. The diagram below shows the energy changes for a reaction with and without a catalyst. Which symbols represent the activation energy, E_a, and the enthalpy change, ΔH, for the reaction with a catalyst?



	E_a **(with a catalyst)**	ΔH
A.	x	z
B.	y	z
C.	z	x
D.	$y - x$	z

21. The following experimental rate data were obtained for a reaction carried out at temperature *T*.

$$A(g) + B(g) \rightarrow C(g) + D(g)$$

Initial [A(g)] / mol dm^{-3}	**Initial [B(g)] / mol dm^{-3}**	**Initial rate / mol dm^{-3} s^{-1}**
3.00×10^{-1}	2.00×10^{-1}	1.89×10^{-2}
3.00×10^{-1}	4.00×10^{-1}	1.89×10^{-2}
6.00×10^{-1}	4.00×10^{-1}	7.56×10^{-2}

What are the orders with respect to A(g) and B(g)?

	Order with respect to A(g)	**Order with respect to B(g)**
A.	zero	second
B.	first	zero
C.	second	zero
D.	second	first

22. Consider the following proposed two-step reaction mechanism at temperature *T*.

Step 1: $2NO_2(g) \xrightarrow{k_1} NO(g) + NO_3(g)$ *Slow*

Step 2: $NO_3(g) + CO(g) \xrightarrow{k_2} NO_2(g) + CO_2(g)$ *Fast*

Which statements are correct?

I. The overall reaction is $NO_2(g) + CO(g) \rightarrow NO(g) + CO_2(g)$.

II. Step 1 is the rate-determining step of the reaction.

III. The rate expression for Step 1 is rate $= k_1[NO_2]^2$.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

23. Which of the following will shift the position of equilibrium to the right in the Haber process?

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H^\ominus = -92.6\,kJ$$

I. Decreasing the concentration of $NH_3(g)$

II. Decreasing the temperature

III. Increasing the pressure

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

24. Which compound has the **highest** molar enthalpy of vaporization?

A. Ethane

B. Ethanoic acid

C. Propane

D. Propanoic acid

25. What are the conjugate acid–base pairs in the following reaction?

$$HCO_3^-(aq) + H_2O(l) \rightleftharpoons OH^-(aq) + H_2CO_3(aq)$$

	Brønsted–Lowry acid	Brønsted–Lowry base	Conjugate acid	Conjugate base
A.	$HCO_3^-(aq)$	$H_2O(l)$	$H_2CO_3(aq)$	$OH^-(aq)$
B.	$H_2CO_3(aq)$	$OH^-(aq)$	$HCO_3^-(aq)$	$H_2O(l)$
C.	$H_2O(l)$	$HCO_3^-(aq)$	$H_2CO_3(aq)$	$OH^-(aq)$
D.	$H_2O(l)$	$HCO_3^-(aq)$	$OH^-(aq)$	$H_2CO_3(aq)$

26. Which group of three compounds contains only weak acids and bases?

A.	$Ba(OH)_2$	CH_3NH_2	CH_3COOH
B.	$CH_3CH_2CH_2COOH$	$CH_3CH_2NH_2$	$HCOOH$
C.	NH_3	HNO_3	CH_3CH_2COOH
D.	NH_3	$NaOH$	H_2CO_3

27. What is the relationship between pK_a, pK_b and pK_w for a conjugate acid–base pair?

A. $pK_a = pK_w + pK_b$

B. $pK_a = pK_w - pK_b$

C. $pK_a \times pK_b = pK_w$

D. $\frac{pK_a}{pK_b} = pK_w$

28. The table below shows data for the K_a and pK_b values for some acids and bases at 298 K.

Acid	$\boldsymbol{K_a}$	**Base**	$\boldsymbol{pK_b}$
HClO	2.9×10^{-8}	NH_3	4.75
$C_6H_5CH_2COOH$	4.9×10^{-5}	$C_6H_5NH_2$	9.13

Which two formulas represent the weakest acid and the weakest base in the table?

A. HClO and $C_6H_5NH_2$

B. $C_6H_5CH_2COOH$ and NH_3

C. $C_6H_5CH_2COOH$ and $C_6H_5NH_2$

D. HClO and NH_3

29. Which pair of compounds could be used to make a buffer solution (assuming appropriate molar ratios)?

A. KCl and HCl

B. $NaCl$ and HCl

C. $KHSO_4$ and H_2SO_4

D. CH_3COONa and CH_3COOH

30. Which salts form acidic solutions when dissolved in water?

I. NH_4Cl
II. $Cr(NO_3)_3$
III. CH_3COONa

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

31. What is the name of MnO_2?

A. Manganese(II) oxide

B. Magnesium(II) oxide

C. Manganese(IV) oxide

D. Magnesium(IV) oxide

32. Consider the following reaction.

$$2Cr(OH)_3(s) + 6ClO^-(aq) \rightarrow 2CrO_4^{2-}(aq) + 3Cl_2(g) + 2OH^-(aq) + 2H_2O(l)$$

Which statement is correct?

A. $Cr(OH)_3$ is the oxidizing agent and the oxidation number of chromium changes from +3 to +6.

B. $Cr(OH)_3$ is the reducing agent and undergoes reduction.

C. ClO^- is the oxidizing agent and the oxidation number of chlorine changes from +1 to 0.

D. ClO^- is the reducing agent and the oxidation number of chlorine changes from –1 to 0.

33. Consider the following two standard electrode potentials at 298 K.

$$Sn^{2+}(aq) + 2e^- \rightleftharpoons Sn(s) \qquad E^\ominus = -0.14\,V$$
$$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq) \qquad E^\ominus = +0.77\,V$$

What is the equation and cell potential for the spontaneous reaction that occurs?

A. $2Fe^{2+}(aq) + Sn^{2+}(aq) \rightarrow 2Fe^{3+}(aq) + Sn(s) \qquad E^\ominus = -0.91\,V$

B. $2Fe^{3+}(aq) + Sn(s) \rightarrow 2Fe^{2+}(aq) + Sn^{2+}(aq) \qquad E^\ominus = +0.91\,V$

C. $2Fe^{2+}(aq) + Sn^{2+}(aq) \rightarrow 2Fe^{3+}(aq) + Sn(s) \qquad E^\ominus = +0.91\,V$

D. $2Fe^{3+}(aq) + Sn(s) \rightarrow 2Fe^{2+}(aq) + Sn^{2+}(aq) \qquad E^\ominus = +1.68\,V$

34. What happens during the electrolysis of concentrated aqueous potassium chloride?

I. Reduction takes place at the negative electrode (cathode).
II. Hydrogen gas is evolved at the negative electrode (cathode).
III. The pH of the electrolyte increases.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

35. What is the name of $(CH_3)_3CCOCH_3$, applying IUPAC rules?

A. 2,2-dimethylbutan-3-one

B. 3,3-dimethylbutan-2-one

C. 2,2-dimethylbutanal

D. 3,3-dimethylbutanal

36. Which functional groups are present in $C_6H_5CONHC_6H_5$?

A. Benzene ring (phenyl), amine

B. Benzene ring (phenyl), ketone, amine

C. Benzene ring (phenyl), amide

D. Alkene, amide

37. What is the product of the reaction when $CH_3CH_2CH_2CH_2CH_2CN$ is reduced by hydrogen, using a nickel catalyst under the appropriate conditions?

A. $CH_3CH_2CH_2CH_2CH_2NH_2$

B. $CH_3CH_2CH_2CH_2CH_2CH_2NH_2$

C. $CH_3CH_2CH_2CH_2CH_2CH_3$

D. $CH_3CH_2CH_2CH_2CH_2CH_2CH_3$

38. What is the major organic product formed from the reaction of $(CH_3)_3CBr$ with a concentrated, ethanolic solution of KOH?

A. $(CH_3)_3COH$

B. $(CH_3)_2CCH_2$

C. $(CH_3)_2CO$

D. $(CH_3)_2CHO$

39. What is the organic product of the reaction between butan-1-ol and ethanoic acid on heating using concentrated sulfuric acid?

A. Butyl methanoate

B. Butyl ethanoate

C. Ethyl butanoate

D. Ethyl propanoate

40. A student measured the mass and volume of a piece of silver and recorded the following values.

Mass of empty weighing bottle	1.0800 g
Mass of weighing bottle with piece of silver	11.5700 g
Volume of silver	1.00 cm^3

Which value, in $g\,cm^{-3}$, for the density of silver should the student report in her laboratory notebook?

A. 10.49

B. 10.4900

C. 10.5

D. 10.500