



Student Number:

2004

HIGHER SCHOOL CERTIFICATE

Sample Examination Paper

CHEMISTRY

General Instructions

Reading time – 5 minutes

Working time – Three (3) hours

Direction to Candidates

- Board approved calculators may be used.
- A Data Sheet and Periodic Table are to be provided with this paper

Section I – Core

Attempt ALL questions.

Part A – (15 marks)

Allow 30 minutes

Mark your answers in pencil on the Answer Sheet provided with this book

Part B – (60 marks)

Allow 1 hour and 45 minutes

Answer this part in the spaces provided in Part B of the Answer Book

Section II – Electives

- Attempt ONE question only
- Each question is worth 25 marks
- Answer the question in a separate Elective Answer Book

Directions to School or College

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All care has been taken to ensure that this examination paper is error free and that it follows the style, format and material content of the new Higher School Certificate syllabus. Candidates are advised that authors of this examination paper cannot in any way guarantee that the 2004 HSC Examination will have a similar content or format.

Section I

PART A – 15 marks

Attempt all questions (1–15)

Each question is worth 1 mark

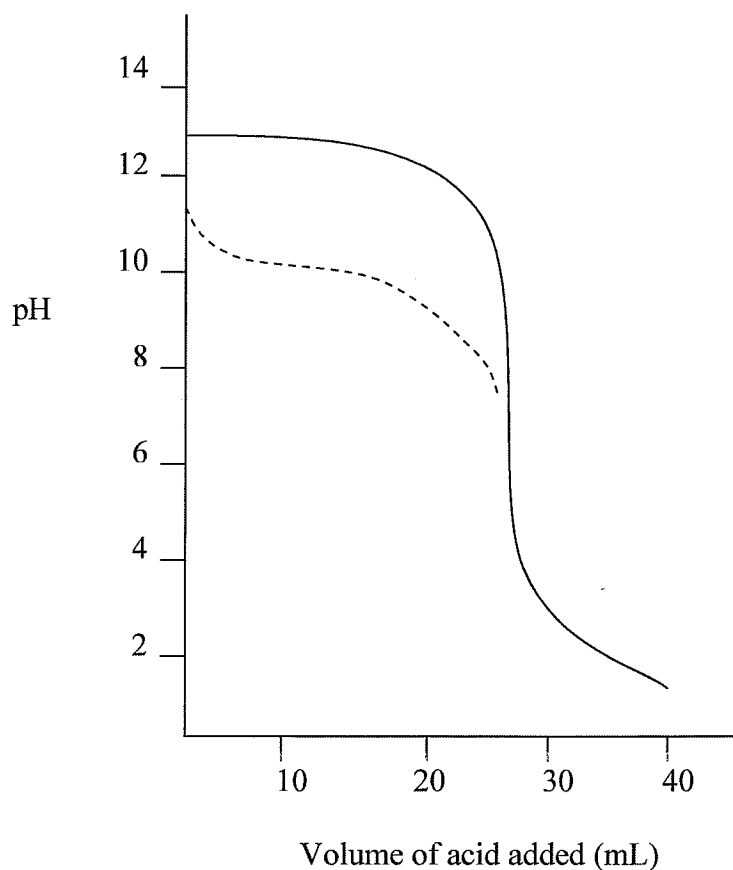
Allow about 30 minutes for this part

Select the alternatives A, B, C or D that best answers the question.

Mark your answers in pencil on the Multiple Choice Answer Sheet provided.

- Which of the following polymers is classified as a condensation polymer
 - polyvinyl chloride
 - high density polyethylene (HDPE)
 - polystyrene
 - polyethene terephthalate (PET)
- Current research involves the development of renewable fuels such as ethanol from biomass. An advantage of the use of ethanol as a fuel is that
 - it reduces toxic emissions to the environment
 - the waste fermentation liquors that result as a byproduct of its production
 - its production involves large areas of agricultural land
 - ethanol in petrol will reduce the octane rating of fuel
- In the voltaic cell given by $\text{Co}|\text{Co}^{2+}||\text{Fe}^{3+},\text{Fe}^{2+}|\text{Pt}$ the cathode would be
 - a piece of cobalt metal
 - a piece of Fe^{3+}
 - a piece of platinum
 - a standard hydrogen electrode
- A salt bridge is used in an electrochemical cell to
 - allow current flow through the cell
 - prevent charge build-up in the half cells
 - prevent direct reaction between oxidising and reducing agent
 - all of the above
- When the neutron to proton ratio in an artificially radioactive isotope is lower than that required for stability, it may obtain stability by
 - alpha emission
 - beta emission
 - gamma emission
 - positron emission
- Consider the following system initially at equilibrium
$$\text{NO(g)} + \text{Cl}_2\text{(g)} \rightleftharpoons \text{NOCl}_2\text{(g)} \quad \Delta H = +21\text{kJ}$$
Which of the following changes would result in the production of additional $\text{NOCl}_2\text{(g)}$
 - increasing the system's volume
 - decreasing the temperature
 - removal of $\text{Cl}_2\text{(g)}$ from the system
 - increasing the system's total pressure

7. The curves in the graph below represent titrations. Note that the solid and dashed curves overlap each other beyond 25 mL



The solid and dashed curves represent the titrations of

- | solid line | dashed line |
|------------------------------|-------------------------|
| A. strong base + strong acid | weak base + strong acid |
| B. strong base + strong acid | strong base + weak acid |
| C. strong base + weak acid | weak base + weak acid |
| D. weak base + strong acid | strong base + weak acid |

8. The conjugate base of the acid, HSO_3^- , is

- A. H_2SO_3
- B. H_2SO_3^-
- C. SO_3^{2-}
- D. SO_3^-

9. Which of the following 0.05M solutions in water would have the greatest concentration of hydroxide ions

- A. NaCl
- B. HNO_3
- C. NH_4Cl
- D. $\text{HC}_2\text{H}_3\text{O}_2$

10. The condensation reaction of ethanol and formic acid will yield as products water and
- dacron
 - methylacetate
 - butyric ester
 - ethyl formate
11. For an equilibrium reaction, the magnitude of K (equilibrium constant) can provide some indication as to the position of equilibrium
- a very large value of K indicates the equilibrium lies to the left
 - a very small value of K indicates the equilibrium lies to the left
 - a very large value of K indicates that few products are formed at equilibrium
 - a very small value of K indicates that few reactants remain at equilibrium
12. Which are the most likely products of the incomplete combustion of a hydrocarbon
- carbon dioxide and water
 - carbon dioxide and hydrogen
 - carbon monoxide and water
 - carbon monoxide and hydrogen
13. Mercury contamination in water systems leads to the concentration of mercury in organisms along the food chain. The instrumental method that would be used to detect the level of mercury contamination in water would be
- atomic absorption spectrophotometry
 - colorimetry
 - density determination
 - ion-selective electrode
14. The abundance of gases in the atmosphere at sea level in increasing order of abundance is
- carbon dioxide, oxygen, neon, argon
 - argon, helium, nitrogen, oxygen
 - carbon dioxide, nitrogen, oxygen, helium
 - methane, neon, carbon dioxide, oxygen
15. The dissolved oxygen (DO) content of a body of water was measured at 5 ppm. Water with this concentration of DO is regarded as moderately polluted. The measured concentration might be dependent upon
- the presence of other solutes in the water
 - the temperature of the water sample
 - the level of organic waste in the water
 - any of the above

PART B – 60 marks

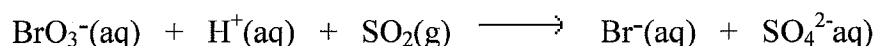
Allow about 1 hour and 45 minutes for this part.

Answer all questions in the spaces provided.

Show working for all questions requiring calculations.

Marks

16. In the unbalanced equation



a. Calculate and show oxidation numbers to determine which species has been oxidised and which has been reduced. **4**

b. Which species is the oxidising agent and which is the reducing agent? **1**

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17. Ethene is a gas at room temperature and pressure. It is highly flammable.

a. i. Ethene is often hydrogenated in the margarine industry to convert unsaturated oils into solid fats which have a greater proportion of saturated molecules. Write an equation for the hydrogenation of ethene. **1**

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ii. What is the name of the reaction process in a. i? **1**

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b. i. Ethene can be polymerised to form polyethylene (polythene). What is meant by polymerise? **1**

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Quest 17. (cont)

b. ii. Write an equation to show the polymerisation of ethene.

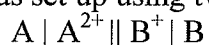
1

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iii. Tetrafluoroethene can be polymerised to form polytetrafluoroethene, PTFE or Teflon. Give the structural formula for tetrafluoroethene AND for a segment of PTFE.

2

18. A galvanic cell was set up using two metals A and B:



A voltmeter showed that metal B was 1.2V positive with respect to metal A.

a. Draw and label a diagram showing what this cell would look like in the laboratory. Indicate on your diagram the direction of flow of electrons.

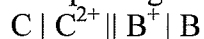
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b. Which metal, A or B, is the strongest reductant? Explain.

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c. A second cell was set up using metals B and C:



In this cell, metal B was 0.4 volts positive with respect to metal C. Arrange the three metals, A, B and C in order of decreasing strength as reductants. Justify your answer.

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19. Tritium (H-3) has been used as a radioactive tracer in studies of water movement.

a. What is a radioactive tracer?

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b. Tritium undergoes beta decay. Write a nuclear equation showing the beta decay of tritium.

1

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c. The half-life of tritium is approximately 12 years. Determine the percentage decrease in activity of this radioisotope in 36 years. Show working.

2

20. A saturated solution of lead sulfate was prepared in a beaker with excess solid, so that after solution a significant amount of lead sulfate solution remained at the bottom of the beaker. If a small amount of lead sulfate labelled with radioactive ^{35}S were now added and the mixture stirred thoroughly.

a. Would the concentration of lead ions in the solution change? Explain.

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Question 20. (cont)

b. After filtering off the solid from the solution, would any radioactivity be detected in the solution? Explain. 2

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21. a. The equilibrium expression $K_w = [H^+][OH^-]$ is the result of two opposing reactions occurring in pure water. Write the two reactions. 2

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b. Give the chemical reason that $[H^+]$ increases as $[OH^-]$ decreases. 2

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c. K_w is larger in seawater than in either pure water or very dilute solutions. At 25°C the pK_w (i.e. the negative logarithm in base 10 for K_w) for seawater is 13.76. Calculate the molar concentration of H^+ in a neutral solution of seawater. 2

22. a. Two monoprotic acids, HX and HY, both 0.100 M in concentration, are titrated with 0.100 M NaOH. The pH at the equivalence point for HX is 8.8 and for HY is 7.9. Which is the weaker acid? Explain. 2

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b. Calculate the mL of 0.0850 M NaOH required to titrate 40.0 mL of 0.0900 M HNO_3 to the equivalence point. 2

23. A student was preparing a sample of an ester, butyl ethanoate, in a laboratory.

a. What would be the alkanol and alkanoic acid used as starting material for this preparation? Give names and formula. 2

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b. For the preparation of the ester a few drops of concentrated sulfuric acid was added to the starting materials and the mixture refluxed for many hours. Why is such a long period of reflux required? 2

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Question. 23. (cont)

c. After the reflux period the resultant product was poured into 250 mL of water in a separation funnel. It was noted that two distinct layers formed in the funnel. In the product mixture would the ester be found in the water layer or the organic layer? Explain.

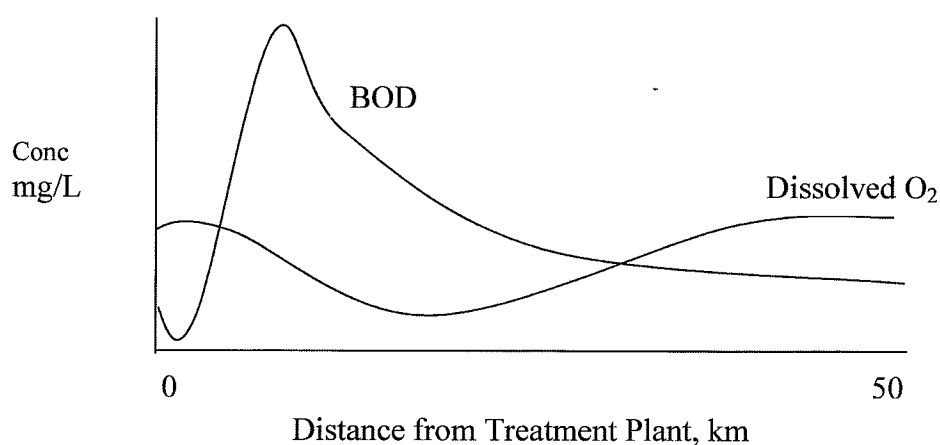
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24. Below is a graph showing the concentration of dissolved oxygen and the 'BOD' level in a creek over a distance of 50 km from a water treatment plant.



a. What is 'BOD' and what information does 'BOD' provide about water quality?

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b. Account for the initial decrease in the concentration of dissolved oxygen shown in the graph.

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Question 24. (cont)

c. Describe a water treatment that could be used to treat 'BOD'. 2

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d. What is eutrophication and how can it contribute to 'BOD'? 2

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25. Draw a schematic diagram of an atomic absorption spectrophotometer labelling the four main components in the spectrophotometer. 4

26. Jacob investigated the reason for the increasing levels of ozone in the middle of the day in the air of the city. He made the following notes:

- Nitrogen monoxide is formed in the combustion chambers of car engines by the reaction of nitrogen and oxygen
- The nitrogen monoxide is emitted in the exhaust and is slowly oxidised by oxygen to form nitrogen dioxide
- Nitrogen dioxide photodissociates rapidly at high UV light intensity to form nitrogen monoxide and oxygen atoms
- Oxygen atoms react with molecular oxygen to form ozone
- Ozone can be destroyed by a slow reaction with nitrogen monoxide to form nitrogen dioxide and diatomic oxygen

a. Write a balanced equation for each of the reactions described by Jacob in his notebook. **5**

b. Explain why ozone levels are highest in the middle of the day.

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SECTION II – OPTIONS

25 marks

Attempt ONE question from questions 27–31

Allow about 45 minutes for this section

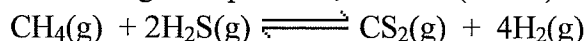
Answer the questions in a writing booklet. Extra writing booklets are available.

Show all relevant working in questions involving calculations.

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Question 27 – INDUSTRIAL CHEMISTRY (25 marks)

a. The following equilibrium between the gases methane, hydrogen sulfide, carbon disulfide and hydrogen exists at high temperature; $K = 2.1 \text{ (mol/L)}^2$ at 1000K



A 1000K mixture contained these four gases at the following concentrations

$[\text{CH}_4] = 0.065 \text{ M}$, $[\text{H}_2\text{S}] = 0.105 \text{ M}$, $[\text{CS}_2] = 0.55 \text{ M}$, $[\text{H}_2] = 0.21 \text{ M}$

- i. Write the equilibrium expression for the reaction. 1
 - ii. Explain why this mixture is not at equilibrium. 1
 - iii. How will the concentration of CH_4 and H_2S change at the mixture moves toward equilibrium? Explain 2
 - iv. This reaction is endothermic. Will the value of the equilibrium constant change as temperature increases? Explain. 2
 - v. Calculate the value of K , at 1000K, for the following reaction at equilibrium 2

$$\text{CS}_2(\text{g}) + 4\text{H}_2(\text{g}) \rightleftharpoons \text{CH}_4(\text{g}) + 2\text{H}_2\text{S}(\text{g})$$
- b. i. Explain, with a diagram, how a surfactant works to ‘solubilise’ dirt and grease on a fabric. 3
- ii. What is the difference between an anionic and cationic surfactant? Note in your answer one common use of each of these types of surfactant. 3
- c. Sodium hydroxide and chlorine are the products of the chlor-alkali industry. Three types of electrolytic cell can be used to produce these products.
- i. State one advantage and one disadvantage of using the mercury cell 2
 - ii. Write the half-equations for the electrode reactions in the mercury cell 2
 - iii. Why is the mercury cell rarely used today? 1
 - iv. State two problems associated with the use of the diaphragm cell 2
 - v. Why is the ion-selective membrane process replacing the diaphragm process? 1
- d. Discuss the human health impact of the use of the mercury-cathode cell in the chlor-alkali industry. Include in your discussion information on how mercury can find its way into the human body and the symptoms of mercury poisoning in humans. 3

Question 28 – SHIPWRECKS, CORROSION and CONSERVATION
(25 marks)

- a. Factors that can affect the products of aqueous solutions of electrolysis are concentrations of solutions and nature of the electrodes.
- i. Discuss the effect of concentration of solution, using as an example the electrolysis of sodium hydroxide solution. 2
 - ii. Discuss the effect of the nature of electrodes, using as an example the electrolysis of an aqueous copper (II) sulfate solution. 2
- b. Two electrolytic cells are connected together in series. The first contains molten sodium chloride and the second aqueous copper (II) sulfate. All the electrodes are made of platinum.
- i. Write balanced half-equations for the reactions taking place at each electrode, clearly stating the polarity of the electrode for each reaction. 4
 - ii. Calculate the total volume of gas produced (measured at STP) when a steady current of 0.50 amps is passed through the two cells for 2 hours and 15 mins. 4
- c. Studies of the process of rusting have shown that
both water and oxygen are required
rusting is accelerated in salt water compared with fresh water
impure iron rusts more rapidly than does pure iron
- i. What is the chemical formula of rust? 1
 - ii. How does rust form? Include in your description the observations above. 4
 - iii. Explain why coating of iron with zinc provides protection against rust. 2
 - iv. Why does aluminium corrode far less rapidly than iron. 2
- d. Objects that have been submerged over a long period of time in seawater are often extensively corroded and in generally very poor condition. Outline the processes employed to restore iron objects that have been long-submerged. 4

Question 29 – THE BIOCHEMISTRY OF MOVEMENT (25 marks)

- a. Carbohydrates are an important part of the human diet.
- i. What is the empirical formula of carbohydrates? 1
 - ii. What is the main function of carbohydrates in the human body? 1
 - iii. Glucose is a carbohydrate monomer which forms a storage polymer glycogen. Describe bond formation between glucose monomers to form glycogen. 3
- b. Fats, important components in cell structure and metabolism, are a special type of ester. Esters are made up of an organic acid and an alcohol.
- i. What is the common name, IUPAC name and structural formula of the alcohol in fats? 3
 - ii. Lauric acid is a C12 fatty acid commonly found in dietary fats. Give its structural formula. 1
 - iii. Write the balanced equation for the fat that would form by the combination of the alcohol in (i) and the acid in (ii). 2
 - iv. What is the role of the oxidation of long-chain fats in body tissue? 1
- c. i. What is an α -amino acid? 1
- ii. How do amino acids react to form peptides? 2
 - iii. Describe the role of hydrogen bonding in determining the α -helix structure of a protein. 2
 - iv. What is meant by protein denaturation? 2
- d. One of the most important molecules in biochemical systems is adenosine triphosphate, ATP. What are the products of the hydrolysis reaction of ATP and what is the biochemical importance of this reaction? 3
- e. Actin and myosin are the contractile filaments in skeletal muscle. Outline the process of contraction in skeletal muscle with particular reference to the initiation of muscle cell contraction and the response of the filaments to this activation. 3

Question 30 – THE CHEMISTRY OF ART (25 marks)

a. 1. Explain the difference between pigments and dyes. Give two examples of each. 3

ii. Describe the general process used to extract and concentrate a pigment. 2

iii. Absorption and reflectance spectra are often used in the study of pigments. How can reflectance spectra be used to determine the presence of a pigment in a painting? 3

b. The following table lists successive ionisation energies (in kilojoules per mole) for three elements A, B and C.

	A	B	C
First ionisation energy	580	502	744
Second ionisation energy	1820	4570	1460
Third ionisation energy	2750	6920	7740
Fourth ionisation energy	11600	9550	10500

i. Why is the second ionisation energy always greater than the first? 2

ii. Why is there a big jump in value between the second and third energies for C and between the third and fourth for A? 2

iii. Write an equation to represent the ionisation of element C. 1

c. i. How does the electron configuration of the transition block elements differ from that of the elements in the main groups of the Periodic Table? 2

ii. Explain why compounds of Ti^{3+} ions are coloured but those of Ti^{4+} are not. 2

iii. The colours of metal complexes depend on the identity of the bonded ligands. Describe with an example. 2

iv. Name a first-row transition element that shows THREE variable oxidation states, showing each of the oxidation states for the element. 2

d. Complex ions are important in biological processes. Blood haemoglobin is such an example. Describe the haemoglobin complex including a reference to how it transports oxygen in the blood. 4

Question 31 – FORENSIC CHEMISTRY (25 marks)

- a. What are the characteristics of DNA that make it particularly useful in forensic investigations? 5
- b. Name four different chromatographic techniques identifying the particular use of each technique in forensic science. 4
- c. Forensic techniques ideally use small amounts of sample and analyse them by non-destructive methods. Discuss. 4
- d. What chemical tests would you use to distinguish the following pairs of compounds?
- i. sucrose and glucose 2
 - ii. hexane and 2-hexene. 2
 - iii. sodium chloride and potassium chloride. 2
- e. Infrared spectra are commonly used by chemists as an aid to the identification of molecules.
- i. What property of molecules give rise to infrared spectra? 1
 - ii. Why do infrared spectra of organic compounds show absorption at many different wavelengths? 2
 - iii. How do forensic chemists use infrared spectra to identify organic compounds? 1
- f. What are some ethical concerns that must be addressed by the forensic scientist? 2

Student Number:

Part	Marks	Out of
A		15
B		60
Elective		25
Total		100

HSC COURSE – 2004 – Sample Examination**CHEMISTRY**
2 Unit

PART A

Select the alternative A, B, C or D that best answers the question.
Mark your answers in pencil on this Answer Sheet.

	A	B	C	D
1	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
14	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
15	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>