ROYAL CIVIL SERVICE COMMISSION

CIVIL SERVICE COMMON EXAMINATION (CSCE) 2008
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALIZATION PAPER for ELECTRICAL & ELECTRONICS GROUP

Date	**:**	**20/12/2008**
Maximum Marks	**:**	**100**
Examination Time	**:**	**2.5 Hours**
Reading Time	**:**	**15 Minutes**

READ THE FOLOWING GUIDELINES CAREFULLY

1. Do not write for the first **15 minutes**. This time must be spent in reading the question paper and to check whether all questions are in order and pages are complete.
2. The maximum time allotted for writing this paper is **150 minutes**
3. All answers to the questions must be written in a separate **Answer Sheet** provided.
4. This paper consists of **TWO** Sections, **Section A** and **Section B**.
5. **Section A** is further divided into **Two Parts, Part I** consisting of **30 Multiple Choice** questions and **Part II** consisting of **4 Short Answer** questions**,** you must **answer ALL of them.** Every correct answer for the questions in Part I shall be awarded ONE (1) mark each, while correct and complete answers to questions in Part-II shall be awarded FIVE (5) marks each.
6. **Section B** contains TWO (2) Case Studies out of which you must **Attempt only ONE (1)**. The Case Study carries 50 marks.
7. While answering the multiple choice questions, write only the letter of the correct answer chosen against the question number, clearly & legibly. Any double writing or smudgy answers shall not be evaluated. E.g.: Q1 – a; Q2 – d; Q3 – a; etc.
8. This paper contains **TEN (10)** printed pages in all, including the Instruction page.

SECTION A

PART I – MULTIPLE CHOICE

Choose the Correct Answer and write down the question number and the letter of the correct answer chosen against it in the Answer Sheet provided.

1. The largest primary source of electrical energy in Bhutan is?

   a) Petroleum b) Coal c) Hydropower d) Biomass

2. Geothermal power plants convert _____ into electricity?

   a) the sun's infra red radiation b) the earth's heat energy
   c) the earth's biomass d) the ocean's tidal energy

3. For the logic diagram given below, which of the following expression is TRUE?

   a) F = (y + z) x b) F = (y' + z) x c) F = x + y'z d) F = x + yz

4. Which of the following defines a Decoder?

   a) It is a combinational circuit that converts binary information from the 'n' coded inputs to maximum of 2^n unique outputs.
   b) It is combinational circuit that receives binary information from one of 2^n input data lines and directs it to a single output line.
   c) It is group of flips-flops with each flip-flop capable of storing one bit of information.
   d) All of the above.

5. Which one describes the effect of temperature on metal conductors?

   a) Rise in temperature will increase the resistance
   b) Rise in temperature will decrease the resistance
   c) Yields positive temperature co-efficient resistance
   d) Both (a) and (c)

6. In the figure given below, when A & B are shorted, the condition of bulbs 1, 2 & 3 will be?

a) All three bulbs glow
b) Bulbs 1 & 2 glows
c) Only Bulb 3 glows
d) None of the bulb glows

7. Identify the 'NOR' gates from the figures given below?

a) Figures 1 & 3
b) Figures 2 & 3
c) Figures 3 & 4
d) Figures 1 & 2

8. A fly wheel stores _____ energy?

a) kinetic
b) potential
c) electrical
d) chemical

9. Electric motors normally _____?

a) multiply electric energy
b) conserve electric energy
c) generate electric energy
d) consume electric energy

10. A 100 watt light bulb consumes _____ in 24 hours?

a) 2.4 BTUs
b) 24 Calories
c) 2400 Calories
d) 2.4 kWh

11. A sine wave of 17 Volts peak is equivalent to how many Volts rms?

a) 29.5 Vrms
b) 24 Vrms
c) 12 Vrms
d) 9.8 Vrms

12. A rough basis for determining the most economical transmission voltage is to use _____ V/km of transmission line?

a) 110 b) 220 c) 415 d) 650

13. The interconnector between two generating stations facilitates to?

a) Keep their voltage constant
b) Run them in parallel
c) Transfer power in either direction
d) Both (b) and (c)

14. The ratio of actual maximum demand made by the load to the rating of the connected load is defined as?

a) Load factor b) Demand factor c) Diversity factor d) Plant factor

15. While calculating the cost of electric power generation, which of the following is NOT considered a fixed cost?

a) Interest on capital investment
b) Taxes and Insurance
c) Most of the salaries and wages
d) Repair and maintenance

16. Transformers are rated in kVA instead of kW because?

a) Load power factor is often not known
b) kVA is fixed whereas kW depends on load p.f.
c) Total transformer loss depends on volt-ampere
d) It is the standard practice of the manufacturer

17. The speed of an alternator is changed from 3600 rpm to 1800 rpm. The generated emf/phases will become?

a) one-half b) twice c) four times d) one-fourth

18. Generally the power loads are inductive, resulting in low power factor (pf) value. Which of the following correcting method is NOT APPLICABLE for pf improvement

a) Static capacitor
b) Synchronous condenser
c) Phase advancers
d) Rectifiers

19. The power in a 3-phase system is given by $\sqrt{3}V_L I_L \text{ Cos } \Phi$. The Φ is the angle between?

a) Line voltage and line current
b) Phase voltage and phase current
c) Line voltage and phase current
d) Phase voltage and line current

20. Which one of the following is MORE TRUE related to the purpose of the surge tank in a hydro electric power plant?

    a) Store the water for emergency or urgent need
    b) Reduce the pressure swings in the conduits
    c) Spillway for the excess water outside
    d) Carry water to turbines

21. A balanced star-connected load of (8 + j6) ohms per phase is connected to balanced 3-phase 400 V supply. The phase voltage, phase current and line current respectively are?

    a) 400V, 40A and 23.1A
    b) 400V, 23.1A and 40A
    c) 231V, 23.1A and 23.1A
    d) 231V, 23A and 13.3A

22. An energy meter makes five revolutions in 20 seconds, whose constant is 600 revolutions per kWh. The load in kW is?

    a) 2 kW
    b) 1.6 kW
    c) 1.5 kW
    d) 1.4 kW

23. Some engineers prefer 'lamps bright' synchronization to 'lamps dark' synchronization because?

    a) Brightness of lamps can be judged easily
    b) It gives sharper and more accurate synchronization
    c) Flicker is more pronounced
    d) It can be performed quickly

24. The power taken by a 3-Φ load is given by the expression?

    a) $3V_LI_L$ Cos Φ
    b) $\sqrt{3}V_LI_L$ Cos Φ
    c) $3V_LI_L$ Sin Φ
    d) $\sqrt{3}V_LI_L$ Sin Φ

25. The chief disadvantage of low power factor is that?

    a) More power is consumed by the load
    b) Current required for given load power is higher
    c) Active power developed by a generator exceeds its rated output capacity
    d) Heat generated is more than the desired amount

26. A complex current wave is given by the equation, $i = 14\text{Sin } \omega t + 2 \text{ Sin } 5\omega t$. The r.m.s. value of the current is ____ A?

    a) 16
    b) 12
    c) 10
    d) 8

27. In a series R-L-C circuit, resonance occurs when?

    a) $R = X_L - X_C$
    b) $X_L = X_C$
    c) $X_L = 10X_C$ or more
    d) net $X > R$

28. An over current relay having a current setting of 125% is connected to a supply circuit through a current transformer of ratio 400/5. What will be the pick-up value?

a) 6.25 A b) 10 A c) 100 A d) 500 A

29. For the protection of delta-star power transformer, the CTs on delta side must be connected in _____ and those on the star side in _____?

a) Star-Star b) Star-Delta c) Delta-Star d) Delta-Delta

30. For 3-phase, 4-pole, 50Hz synchronous motor the frequency, pole numbers and load torque are all halved. The motor speed will become?

a) 575 rpm b) 875 rpm c) 1500 rpm d) 3000 rpm

PART II – SHORT ANSWER TYPE

1. A filament for a 240V lamp is to be constructed using a wire of length 54 cm and having a diameter of 0.02 mm and the resistivity at 20°C is 4.3 μ Ω-cm. If the temperature coefficient of resistance (α) is 0.005/°C, what would be the power dissipated by the lamp, assuming the filament temperature of 2420°C?

2. List and explain briefly the factors affecting corona in a transmission line? What is critical disruptive voltage?

3. A factory has a maximum load of 240 kW at 0.8 p.f. lagging with an annual consumption of 50,000 units. The tariff is Nu. 50 per kVA maximum demand plus Nu. 1.30 per unit. Calculate the following:

   i) The maximum demand in kVA?
   ii) Annual electricity charges?
   iii) Annual savings if p.f. is raised to unity?

4. A 2-to-4-line decoder with an enable input is constructed using NAND gates as shown in the figure below. Complete the truth table for the given inputs?

E	A_1	A_0	D_0	D_1	D_2	D_3
0	0	0				
0	0	1				
0	1	0				
0	1	1				
1	x	x				

SECTION B – CASE STUDY

[Answer only One (1) Question]

Q1. The western Power system of Bhutan consists of various generating stations and transmission lines interconnected in such a way that 80% of the energy generated by the two largest stations is exported to India while the energy from the two other generating stations are consumed internally. The energy is exported to India through a set of 220kV and 400kV lines. The supplies for internal consumptions are realized through transmission systems of 66 kV and below.

i) Generate a detailed single-line diagram of the western power system showing generating stations, generator and substation transformers, loads supplied and export lines, if the power system network consists of the following:

a) Generating Plants:

i) 336 MW (4x84MW) Chhukha Hydropower Plant, Generated Voltage – 11kV
ii) 24 MW (2x12MW) Basochhu Hydropower Plant, Generated Voltage – 11kV
iii) 40 MW (2x20MW) Rurichhu Hydropower Plant, Generated Voltage – 11kV
iv) 1020 MW (6x170MW)Tala Hydropower Plant, Generated voltage – 13.8kV

b) Transmission system:

- Chhukha is connected with Rurichhu through a 220 kV line via Semtokha substation and most of the western Dzongkhags receive power supply from the Semtokha substation via 66kV lines.

- Chhukha is connected to the Indian grid at Birpara through the 220kV double circuit (D/C) line, through which Chhukha power is exported to India.

- Chhukha is also connected to the Malbasse substation through a 220kV line from where it is again connected to Indian grid at Birpara through a 220 kV line forming another export line.

- Tala is directly connected to the Indian grid at Siliguri through a 400kV (D/C) and 400kV single circuit (S/C) transmission lines, through which Tala power is exported to India.

- Tala is also connected to the Malbasse substation through a 400kV S/C transmission line and from Malbasse it is again connected to Indian grid through a 400kV S/C transmission line by LILO arrangement at the Malbasse substation.

- Chhukha and Tala are interconnected at the Malbasse substation through a 400/220/33 kV 3-winding transformer.

- Power supplies to Pasakha Industrial estate is met from the Malbasse substation via 66kV and power supplies to Bhutan Ferro Alloys and Bhutan Calcium &

Carbide factories are drawn from the 66kV Singhegaon substation which is connected to 220kV Malbasse substation by a 220kV transmission line.

ii) If the generators are designed for p. f. of 0.9, estimate the MVA ratings of the generator (step up) transformers located at each generating station considering there is 10% overload generation at each plant?

iii) Indicate the PV, PQ & Slack buses if any and specify the power and voltage levels at the generator buses, e.g., Chhukha buses can be indicated as C1 (336MW,11kV), C2 (220kV), etc.

iv) If the combined energy generation of the above generating stations is 4,125 Million Units (MU) in a particular year and the population of the country is estimated as 650,000, find the per capita annual energy generated by the western generation system in kWh?

Q2. A run-of-the-river hydropower project, without storage has been identified by the feasibility study team consisting of consulting engineers, environmentalists, administrators, and economists. The study team came out with the following data pertaining to this potential project:

i) Discharge (Q) = 300 m^3/s
ii) Gross Head (H) = 100 m
iii) Penstock, turbine & Generator efficiencies = 96%, 90% and 98%

a) Draw a schematic arrangement of all the critical components or constituents of the hydro-electric plant, labeling them and explaining each of them briefly? In your opinion, what environmental concerns will have to be taken into account while constructing the project and outline the mitigation measures that should be adopted? What in your opinion are the advantages of the run-of-the-river project over the reservoir dam type projects?

b) Find the power availability from this project in MW using the equation, $P = \rho \times Q \times g \times H$; where you are required to use standard values for density (ρ) of water and

acceleration of gravity (g). What would be the firm capacity of the project given the component efficiencies and find the annual energy available? In addition, how many generating units should the project have and what would be optimal capacities in MW?

c) If the project is scheduled to sell its electricity to a power trading company at a rate of Nu.1.50 per unit, what would be the revenue from this sale? Further, if the plant has to shut down for two months in summer due to a major flood, what would be the energy generation for that year assuming the plant was shut down in the months of June and July? Calculate the loss incurred to the project as a result of this calamity?

d) What should be the approximate capacity in MVA of the generator transformers to step-up the transmission voltage to 220kV, given the number of units and the size of synchronous generators selected earlier? You must assume that generators are rated at a power factor of 0.9 and a rated voltage of 11kV with a 10% continuous overloading capacity.
