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**EE.EES.460 Electrical Energy Storages and Electric Vehicles, 5 cr.**

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Answer all the **five (5)** questions. The use of calculator is allowed. Answers in Finnish or English.

1. Answer TRUE or FALSE (+0.5 for correct answer, -0.5 for incorrect, 0 for empty, total max 6 p.)
  1. Global oil consumption has started to decrease in the past 5 years.
  2. Lead-acid batteries are safer than lithium-ion batteries
  3. Lithium-ion battery will instantly "die" if put to over 80 °C
  4. C-rate describes the battery's maximum charging current
  5. All lithium-ion battery chemistries have same voltage
  6. Specific energy is rated in Wh/kg or Wh/litre
  7. Series hybrid vehicle can't move if electric motor is broken
  8. Passenger EV energy consumption is ca. 0.2 kWh/km
  9. Charging power can be adjusted in all EV charging standards (AC and DC)
  10. Type 2 plug is for AC charging and CCS2 for DC charging
  11. Energy storages can be provided to multiple market places simultaneously in Finland
  12. Charging infra design and batteries are harder than motor and inverter choices when considering electrification of vehicles.
2. Energy storages (6 p.)

Why has pumped hydro storage been the largest energy storage methodology? What are its benefits compared to other options? How will large scale lithium battery energy storages change grid storage potential both from technical and economical perspective?
3. Batteries (6 p)
  - a) Explain **in detail** and with illustration and in writing how charging and discharging a lithium-ion battery works. Describe the parts of the batteries and phenomena that happens. (4 p)
  - b) Explain briefly how dual layer capacitors are different from lithium-ion batteries. (2 p)
4. Electric vehicles (6 p.)
  - a) Imagine yourself to be responsible for deciding about city bus electrification. What are the things to be considered to make a viable product? (3p)
  - b) Describe how electric vehicle charging will affect the whole electrical power system (3p)

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5. Financial value and investing (6 p.)

Heavy duty machine electrification in underground mine. What is the net present value of diesel and electric options given the numbers in the table?

	Diesel	Electric
Machine cost	1 000 000	1 400 000
Energy consumption per year	50 000 litres	100 000 kWh
Energy cost	1 €/l	0,20 €/kWh
Savings in ventilation energy		250 000 kWh
Battery replacement cost		100 000 € (every 5 years)
Charger cost (lifetime)		100 000 €

Expected life time for the vehicle is 15 years. Discount rate is 7%

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