**Question 1.**

**(a) Consider the following RDF/XML file:**

<?xml version="1.0"?>

<!DOCTYPE rdf:RDF [

<!ENTITY ex "http://example.org/ontology/">

]>

<rdf:RDF

xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"

xmlns:ex="http://example.org/ontology/"

xml:base="http://example.org/data">

<rdf:Description rdf:ID="john">

<rdf:type rdf:resource="&ex;Person"/>

<ex:name>John Smith</ex:name>

<ex:studiesAt rdf:resource="#lowlands"/>

</rdf:Description>

<rdf:Description rdf:about="#john">

<ex:hasTutor>

<rdf:Description>

<rdf:type rdf:resource="&ex;Person"/>

<ex:name>Dr George Bunn</ex:name>

</rdf:Description>

</ex:hasTutor>

</rdf:Description>

<rdf:Description rdf:ID="lowlands">

<ex:name>Lowlands University</ex:name>

</rdf:Description>

</rdf:RDF>

**(i) In N-Triples or Turtle, list the triples that are generated when this file is parsed. [7 marks]**

<john> <type> < http://example.org/ontology/Person>

\_:john <http://example.org/ontology/name> “John Smith”

\_:john studiesAt Lowlands

\_:lowlands hasName “Lowlands University”

**(ii) Show how the RDF/XML from part (a)(i) can be abbreviated. [5 marks]**

**(iii) The ontology referenced at http://example.org/ontology/ is defined in Turtle as follows:**

@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .

@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .

@prefix ex: <http://example.org/ontology/> .

ex:Person rdf:type rdfs:Class.

ex:Academic rdf:type rdfs:Class;

rdfs:subClassOf ex:Person.

ex:Student rdf:type rdfs:Class;

rdfs:subClassOf ex:Person.

ex:Organisation rdf:type rdfs:Class.

ex:University rdf:type rdfs:Class;

rdfs:subClassOf ex:Organisation.

ex:name rdf:type rdf:Property.

ex:memberOf rdf:type rdf:Property.

ex:studiesAt rdf:type rdf:Property;

rdfs:subPropertyOf ex:memberOf;

rdfs:domain ex:Student;

rdfs:range ex:University.

ex:hasTutor rdf:type rdf:Property;

rdfs:domain ex:Student;

rdfs:range ex:Academic.

**In N-Triples or Turtle, list the triples that are entailed by the file with the ontology under the RDFS semantics.**

**You should ignore any entailments that arise directly from the RDFS axiomatic triples. [8 marks]**

**(b) The following OWL file contains a simple ontology.**

<?xml version="1.0"?>

<!DOCTYPE rdf:RDF [

<!ENTITY owl "http://www.w3.org/2002/07/owl#">

]>

<rdf:RDF

xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"

xmlns:owl="http://www.w3.org/2002/07/owl#"

xml:base="http://example.org/ontology">

<rdf:Property rdf:ID="hasChild"/>

<owl:Class rdf:ID="Parent">

<owl:equivalentClass>

<owl:Class>

<owl:intersectionOf rdf:parseType="Collection">

<owl:Class rdf:ID="Person"/>

<owl:Restriction>

<owl:onProperty rdf:resource="#hasChild"/>

<owl:someValuesFrom rdf:resource="&owl;Thing"/>

</owl:Restriction>

</owl:intersectionOf>

</owl:Class>

</owl:equivalentClass>

</owl:Class>

</rdf:RDF>

**Into which OWL sublanguage does this ontology fall, and why? How could the ontology be changed to make it fall within the OWL Lite sublanguage? [7 marks]**

**(c) Describe three expressive features supported by OWL 2 that are not available in OWL. [6 marks]**

**Question 2.**

**(a) Consider an RDF triplestore containing the following graph. The URI of the graph is http://example.org/data/phones.n3**

@prefix ex: <http://example.org/ontology#> .

:GOOG rdf:type ex:Company ; ex:name "Google Inc." .

:MMI rdf:type ex:Company ; ex:name "Motorola Mobility, Inc." .

:AAPL rdf:type ex:Company ; ex:name "Apple Computer Inc." .

:NOK rdf:type ex:Company ; ex:name "Nokia" .

:MSFT rdf:type ex:Company ; ex:name "Microsoft Corporation." .

:wp7 rdf:type ex:OperatingSystem ;

ex:name "Windows Phone 7" ; ex:manufacturer :MSFT .

:and rdf:type ex:OperatingSystem ;

ex:name "Android" ; ex:manufacturer :GOOG .

:ios rdf:type ex:OperatingSystem ;

ex:name "iOS" ; ex:manufacturer :AAPL .

:lum920 ex:name "Lumia 920" ; ex:manufacturer :NOK ;

ex:screen "4.5"^^xsd:decimal ; ex:os :wp7 ;

ex:rrp "520"^^xsd:decimal ; rdf:type ex:Phone .

:lum800 ex:name "Lumia 800" ; ex:manufacturer :NOK ;

ex:screen "3.7"^^xsd:decimal ; ex:os :wp7 ;

ex:rrp "520"^^xsd:decimal ; rdf:type ex:Phone .

:ip5 ex:name "iPhone 5" ; ex:manufacturer :AAPL ;

ex:screen "4"^^xsd:decimal ; ex:os :ios ;

ex:rrp "530"^^xsd:decimal ; rdf:type ex:Phone .

:ip4s ex:name "iPhone 4S" ; ex:manufacturer :AAPL ;

ex:screen "3.5"^^xsd:decimal ; ex:os :ios ;

ex:rrp "450"^^xsd:decimal ; rdf:type ex:Phone .

:razi ex:name "RAZR i" ; ex:manufacturer :MMI ;

ex:screen "4.3"^^xsd:decimal ; ex:os :and ;

ex:rrp "340"^^xsd:decimal ; rdf:type ex:Phone .

:razhd ex:name "RAZR HD" ; ex:manufacturer :MMI ;

ex:screen "4.7"^^xsd:decimal ; ex:os :and ;

ex:rrp "480"^^xsd:decimal ; rdf:type ex:Phone .

**(i) Give the bindings for the following SPARQL query when evaluated against the graph:**

PREFIX ex: <http://example.org/ontology#>

SELECT ?name, ?manufacturer

WHERE { ?phone ex:name ?name .

?phone ex:manufacturer ?manufacturer . }

**[4 marks]**

**(ii) Write a SPARQL query that returns the name of the manufacturer of the phone named “iPhone 5”. [4 marks]**

**(iii) Write a SPARQL query that returns the name of every phone costing (with a recommended retail price) less than GBP 500. [4 marks]**

**(iv) Write a SPARQL query that returns the name (and screen size, if listed) of every phone costing less than GBP 500. [4 marks]**

**(v) Write a SPARQL query that returns the screen size and RRP**

**of phones that run the ”Windows Phone 7” operating system, in ascending order of price. [4 marks]**

**(vi) Write a SPARQL query that returns the companies who manufacture both phones and operating systems. [4 marks]**

**(vii) A second graph is added to the triplestore, with the URI**

http://example.org/data/phones2.n3

@prefix ex: <http://example.org/ontology#> .

:gs3 ex:name "Galaxy S III" ; ex:manufacturer :SMSG ;

ex:screen "4.8"^^xsd:decimal ; ex:os :and ;

ex:rrp "390"^^xsd:decimal ; rdf:type ex:Phone .

:SMSG rdf:type ex:Company ; ex:name "Samsung" .

**Write a SPARQL query that returns the names of only those phones running ”Android” that are described in the second graph. [5 marks]**

**(b) Briefly describe two features supported by SPARQL 1.1 that are not available in SPARQL. [4 marks]**

**Question 3.**

**(a) Ontologies frequently need to model descriptive features of objects.**

**For example, an ontology for an online retailer might associate one of a fixed number of delivery methods (economy, priority, express) with each order. Describe an ontology pattern which could be used to model such a feature, and illustrate its use with an example.**

**[10 marks]**

**(b) The online retailer in part (a) decides to offer variants of its express delivery method: a before-noon express delivery, and a next-day express delivery. Show how your pattern can be extended to model such subdivisions. [6 marks]**

**(c) Consider a tourist information system that can be used to answer questions about points of interest (such as tourist attractions) that lie within a hierarchy of geographical regions (towns, counties, countries), where those points of interest are classified by type (museum, gallery, zoo, historic house, theme park).**

**Sketch an ontology that could be used for representing information in this system, identifying the ontology patterns you use, and the types of queries that your ontology will be able to answer (SPARQL may be used to express the queries, but is not mandatory). [17 marks]**

**Question 4.**

**(a) Consider the following HTML5 document with RDFa 1.0 markup:**

<html xmlns="http://www.w3.org/1999/xhtml"

xmlns:dbo="http://dbpedia.org/ontology/"

xmlns:dbr="http://dbpedia.org/resource/"

xmlns:dc="http://purl.org/dc/elements/1.1/"

xmlns:foaf="http://xmlns.com/foaf/0.1/"

xmlns:ex="http://example.org/ontology/">

<head><title>O Lucky Man!</title></head>

<body about="dbr:O\_Lucky\_Man!" typeof="dbp:Film">

<h1><span property="dc:title">O Lucky Man!</span> (1973)</h1>

<p property="dbo:director" resource="dbr:Lindsay\_Anderson">

Directed by <span about="dbr:Lindsay\_Anderson"

property="foaf:name">Lindsay Anderson</span>.</p>

<h2>Broadcasts</h2>

<ul rel="ex:broadcast">

<li typeof="ex:Event" about="#b1">

<span property="ex:start" content="2013-02-16T20:00:00"

datatype="xsd:dateTime">8pm 16th February 2013</span>

on <a href="http://channel6.com/">Channel 6</a></li>

</ul>

</body>

</html>

**In N-Triples or Turtle, give the graph which may be extracted from this fragment. [10 marks]**

**(b) Amend the XHTML document in part (a) to encode the following additional triples:**

<dbr:O\_Lucky\_Man!> dbo:released "1973-06-20"^^xsd:date .

<#b1> ex:channel <http://channel6.com/> .

**[8 marks]**

**(c) The online retailer http://acme.org/ wishes to publish RDF descriptions of its products.**

**Each product will be assigned a URI of the form http://id.acme.org/product/<id> that will redirect to either an HTML page (perproduct, published at http://acme.org/product/<id>) or to a single RDF catalogue that describes all the products (at http://data.acme.org/) based on the content-type requested by the web client.**

**Describe a recipe for publishing RDF data that would support such behavior, specifying the exchanges of HTTP messages between server and client that would be observed, and show how it could be used to implement the proposed website. [15 marks]**

**Question 5.**

**(a) Description logics may be considered to be fragments of first-order predicate logic (FOPL). Show how the following DL axiom may be expressed in FOPL:**

**Happy u Parent v Person u 9hasChild:Healthy [5 marks]**

**(b) Consider the following interpretation consisting of a set \_ (the domain of discourse) and an interpretation function ext:**

\_ = f a; b; c; d; e; f; g; h g

ext(A) = f b; c; d; e g

ext(B) = f d; e; f; g g

ext(R) = f hb; ai; hb; fi; hc; gi; hf; bi; hg; ci; hg; hi g

ext(S) = f hd; ai; hd; ci; hd; ei; he; di; he; fi; he; hi g

Give the values of ext for the following class expressions:

(e.g. ext(A u B) = f d; e g):

(i) ext(:B) [2 marks]

(ii) ext(B u :A) [2 marks]

(iii) ext(\_ 2 R) [2 marks]

(iv) ext(9R:B) [2 marks]

(v) ext(8R:B) [2 marks]

(vi) ext(9S:(9R:B)) [2 marks]

(vii) ext(9S:>) [2 marks]

**(c) (i) A Martian is an alien that comes from the planet Mars [2 marks]**

**(ii) Every Martian has either green skin and blue eyes, or blue skin and green eyes [2 marks]**

**(iii) Every Martian carries a raygun [2 marks]**

**(iv) A flying saucer is a Martian spacecraft [2 marks]**

**(v) Only Martians can pilot flying saucers [2 marks]**

**(vi) No Martian can swim [2 marks]**

**(vii) Blue Martians are afraid of ducks [2 marks]**